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FINAL REPORT, 16 Oct 74 - 1 Mar 78

FOR

CONTRACT N00014-75-C-0107

MIDWATER ACOUSTIC MEASUREMENT SYSTEM - PAR AND ACODAC.

28 FEB[redacted] 1978

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I. Introduction

This report describes the work performed by Texas Instruments under Contract N0004-75-C-0107 during the period 16 October 1974 to 1 March 1978. Contract N00014-75-C-0107 includes the development and construction of the Programmable Acoustic Recorder (PAR) electronics together with the development of operational software. Effort under this contract also includes acceptance testing of the PAR system electronics; PAR mechanical design, construction, and testing; underwater cable and hydrophone/pre-amp assembly design and construction; and a refurbishment of the Acoustic Data Capsules (ACODAC), S/N's 002 and 005.

II. Purpose

Specific requirements of the contract are shown to be satisfied as follows:

Sequence number A001, Status of Funds Report of the Contract Data Requirements List (CDRL) had been deleted in modification P00003.

Sequence number A002, Final Report of Systems Design Phase I, was deleted in modification P00004.

Sequence numbers A003 and A004, Computer Software Listing and the Operator's and Maintenance Manual, were completed on 25 March 1977 and submitted as the PAR Electronics Manual.

Sequence number A005, Final Technical Report, shall be satisfied with this report.

Sequence number A006, Progress Reports, have been submitted as required, and have been forwarded under separate cover or presented at briefings.

Sequence number A007, Software Instructions and Operator's Manual, was submitted for customer approval on 31 October 1977.

III. Programmable Acoustic Recorder Technical Summary

The PAR system is a microprocessor-controlled midwater acoustic measuring and recording system. Specific considerations for the development of the PAR electronics and its support equipment are listed in Attachment 1 of P00005 (revised from Attachments 1 of P00001 and P00002). All of these characteristics have been incorporated into the PAR system. Detailed descriptions of the various circuits of the PAR system are found in the PAR

Electronics Manual (Sequence number A004). Task 1 of P00006 calls for an acceptance test of the PAR electronics to be performed, and a data analysis to be done on the magnetic tapes produced from this test. Results of this task are included in this report. Task 2 of P00006 was the Computer Software Development (Sequence number A003) and the results are also in the PAR Electronics Manual.

Specifications for mechanical designs of the PAR, along with electronic and electromechanical hardware associated with PAR's and ACODAC's, are listed in Attachment III of P00007. The center rings and pre-amp housings had special procedures for construction and testing to insure operation in the hostile temperatures and pressures deep in the ocean. Tests on EM cable led to a redesign using a differential transmission line for better crosstalk characteristics. This resulted in the design of a differential input buffer. New pre-amps with a calibration feature and pre-settable functions, (shot/ambient recording, adjustable gain and bandwidth) were designed to complement the differential input buffers.

IV. Programmable Acoustic Recorder Characterization Study

The PAR electronics packages have been tested to define operational characteristics and performance. This characterization test was performed in two steps. First, the systems were optimized under environmental conditions. Then the characterization and performance parameters of the system were measured. Optimization of the PAR tape recording system consisted of determining the optimum bias record and reference marker levels. System characterization consisted of determining the linear dynamic range, gain linearity, frequency response, frequency modulation noise, self noise, harmonic distortion, intermodulation distortion, and interchannel crosstalk.

A. System Preparation

Data for determining the optimization parameters was recorded on each system under environmental conditions, while data for determining the characterization parameters was recorded on each system under both laboratory and environmental conditions. Under laboratory conditions the PAR electronics and tape recording systems operated at atmospheric temperature, pressure and humidity with no attempt being made to control these parameters. Under environmental conditions the PAR electronics and recording systems were placed in an environmental chamber where a constant temperature of 0^{o}C, pressure of 16 in. mercury, and humidity less than 10% were maintained. Additionally

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the tape recording package was shock mounted on a vibration isolating base.

After performing the system functional checks and alignment as provided in the PAR Acceptance Test Procedure No. 2024211, data for system optimization was recorded using the configuration shown in Figure 1. The PAR systems were adjusted to the optimum bias and record levels, and the characterization data was then recorded with the configuration of equipment shown in Figure 2. All data was recorded on new Ampex 787 tapes degaussed with the GKI Model K-80 magnetic tape eraser.

B. Data Quality

The system used for recording data for the characterization study (Figure 2) included a circuit to compensate the input signal for the effects of pre-emphasis in the PAR electronics package. When the circuit was loaded by the PAR electronics package it malfunctioned and overloaded, producing an output waveform as shown in Figure 3. The asymmetric shape of the output waveform emphasized the even harmonics while the squared off negative lobe emphasized the odd harmonics. The problem was not discovered and corrected until all data for system 1 in both the laboratory and environmental chamber had been recorded. Data recorded on system 2 in the environmental chamber, with the exception of the interchannel crosstalk data, is also contaminated. Only system 2 data recorded in the laboratory is completely free of the problem.

The extent of the problem is illustrated by comparing Figures 4,5,6, and 7 which show the spectra of 25 Hz and 100 Hz tones recorded on system 2 at a 0.3 VRMS (-10dB) level under laboratory and environmental conditions. The second and third harmonics are quite obvious under environmental conditions where the pre-emphasis compensation circuit is overloaded and they disappear under laboratory conditions where the overload is eliminated.

Even though the harmonic content of the data is severly contaminated, some useful data can be recovered from these tapes. Since Figures 4 through 7 show that the magnitude of the main lobe was not affected, the linear dynamic range, gain linearity, and interchannel crosstalk can be determined. The white noise signal used for the frequency response characterizations was also severly distorted and useless on those sections recorded before the problem was repaired; however, the linear dynamic range data does provide a limited amount of data from which frequency response can be inferred. Self noise data is uncontaminated since the inputs to the PAR electronics were grounded at the signal source test set (See Figure 2), hence these determinations can be made.

Figure 1. PAR Recorder Optimization Test Set-Up

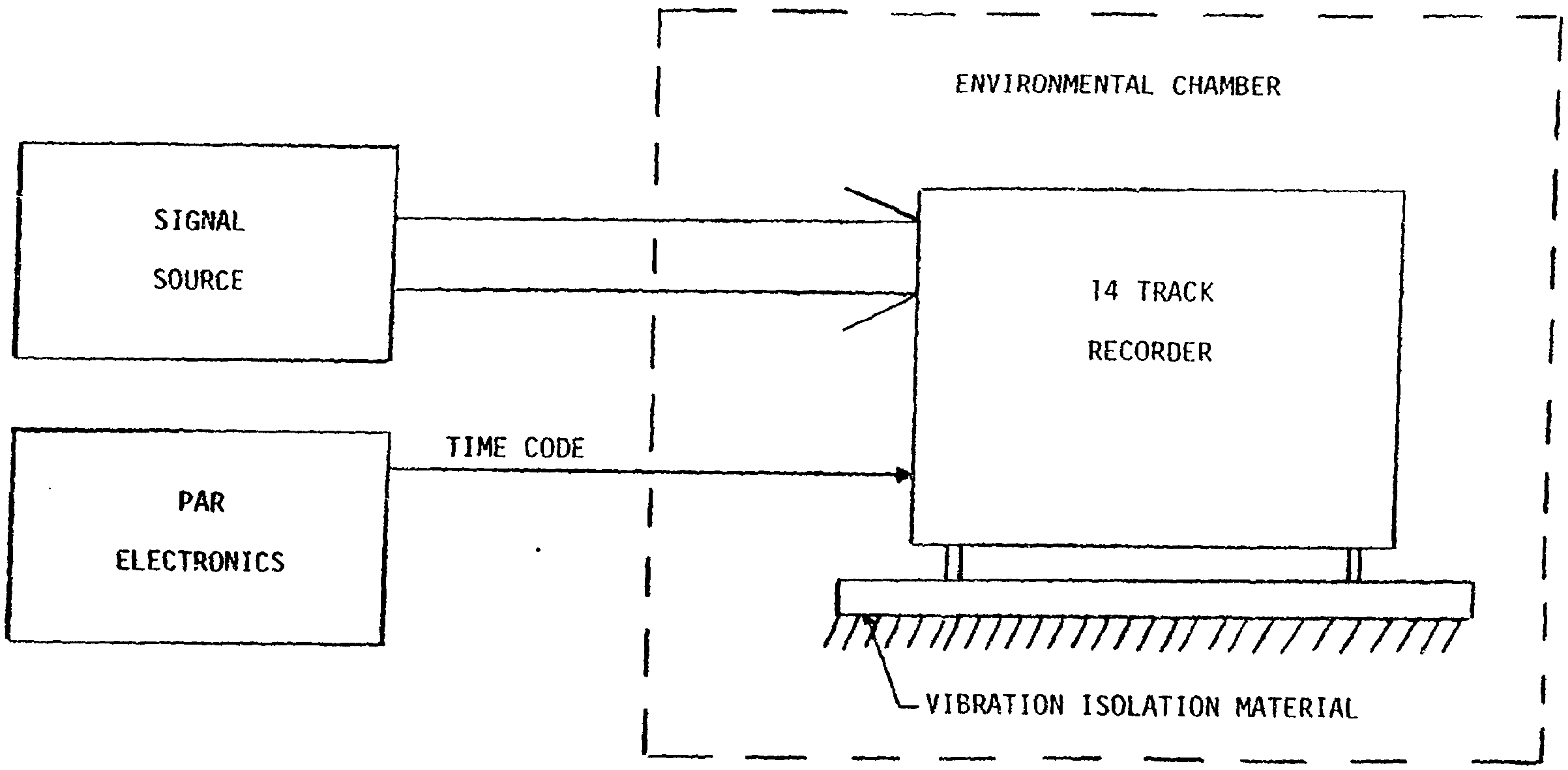


Figure 2. PAR System Characterization Test Set-Up

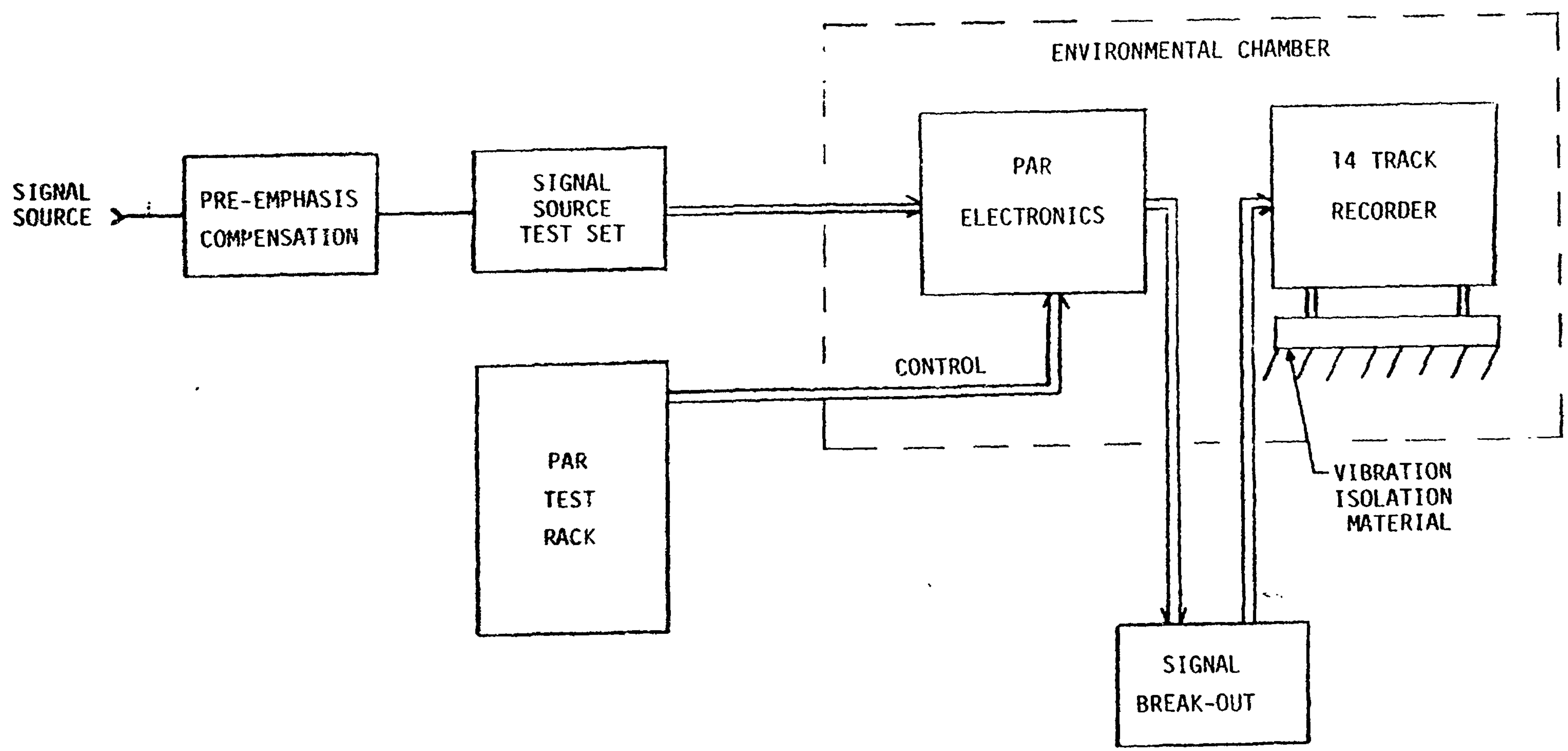


FIGURE 3. PRE-EMPHASIS COMPENSATION CIRCUIT RESPONSE

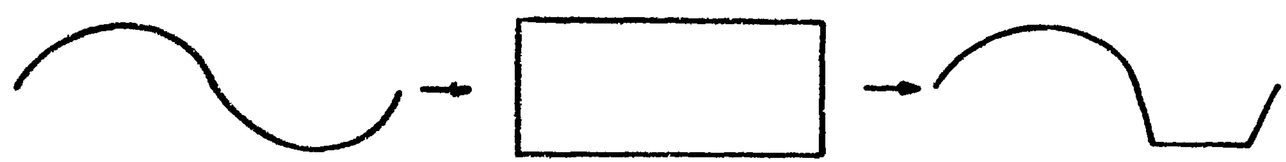


FIGURE 4. PAR SYSTEM 2 ENVIRONMENT CHANNEL 13 25HZ 0.3V

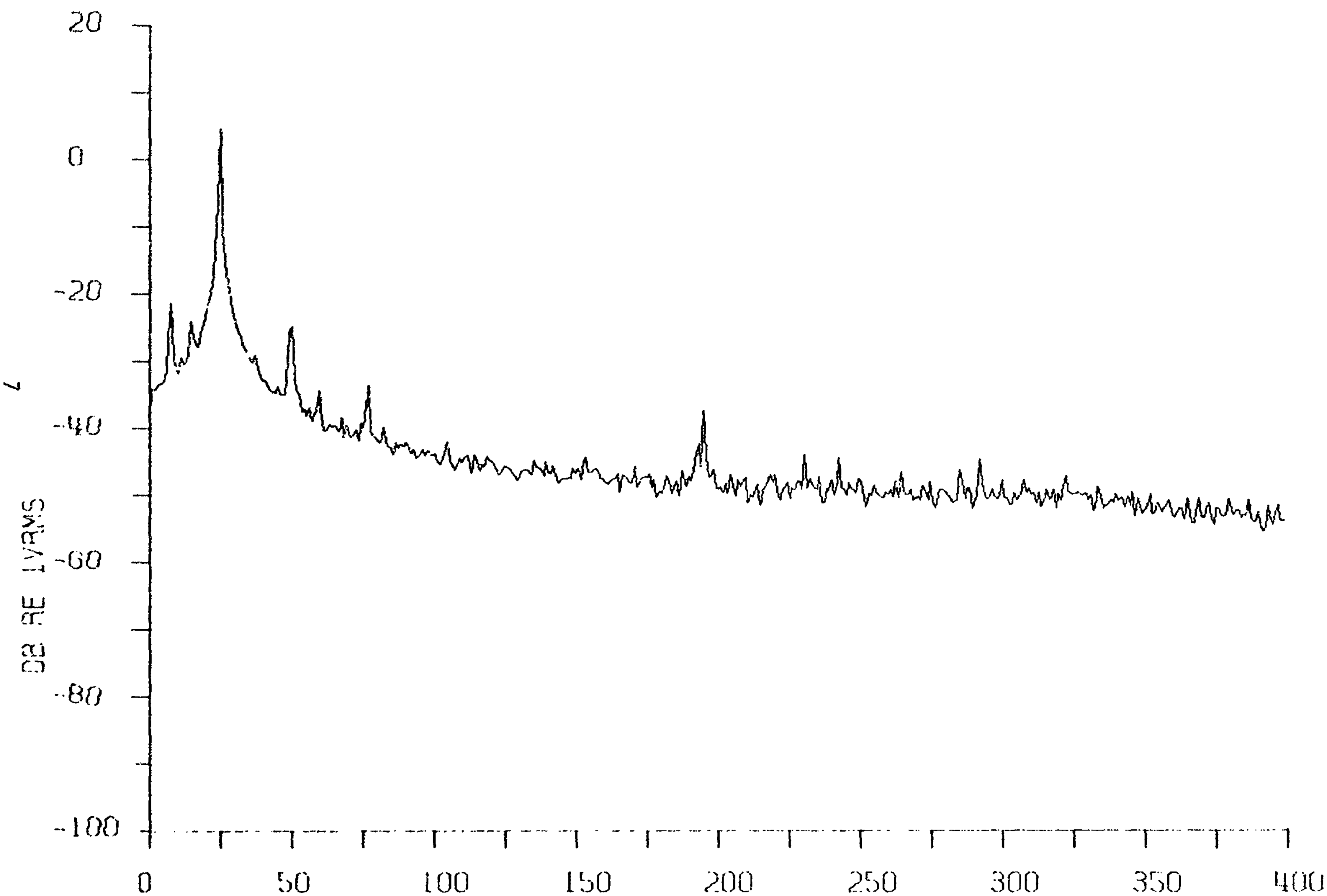


FIGURE 5. PAR SYSTEM 2 LAB CHANNEL 13 25HZ .3VRMS

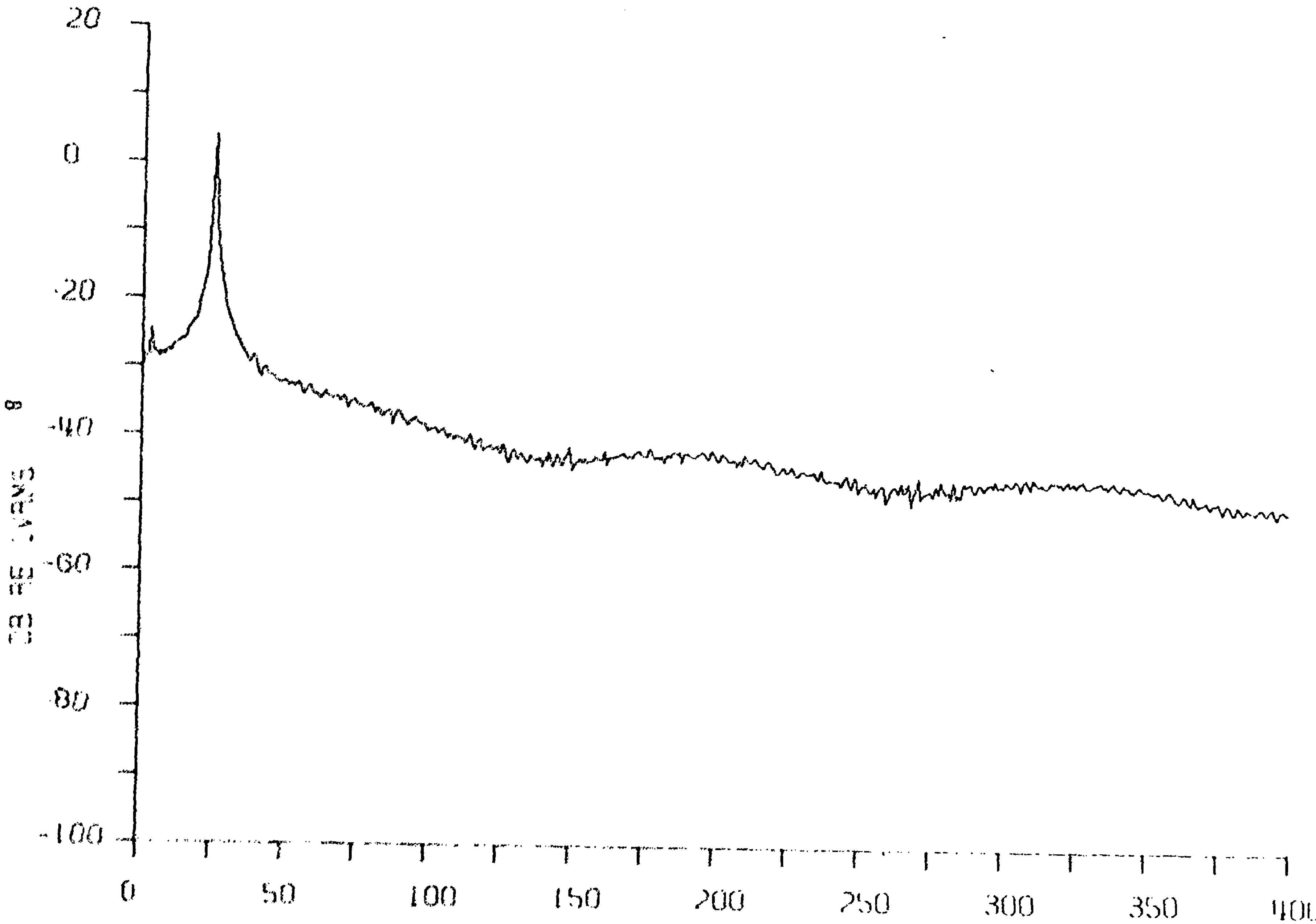


FIGURE 6. PAR SYSTEM 2 ENVIRONMENT CHANNEL 13 100HZ 0.3V

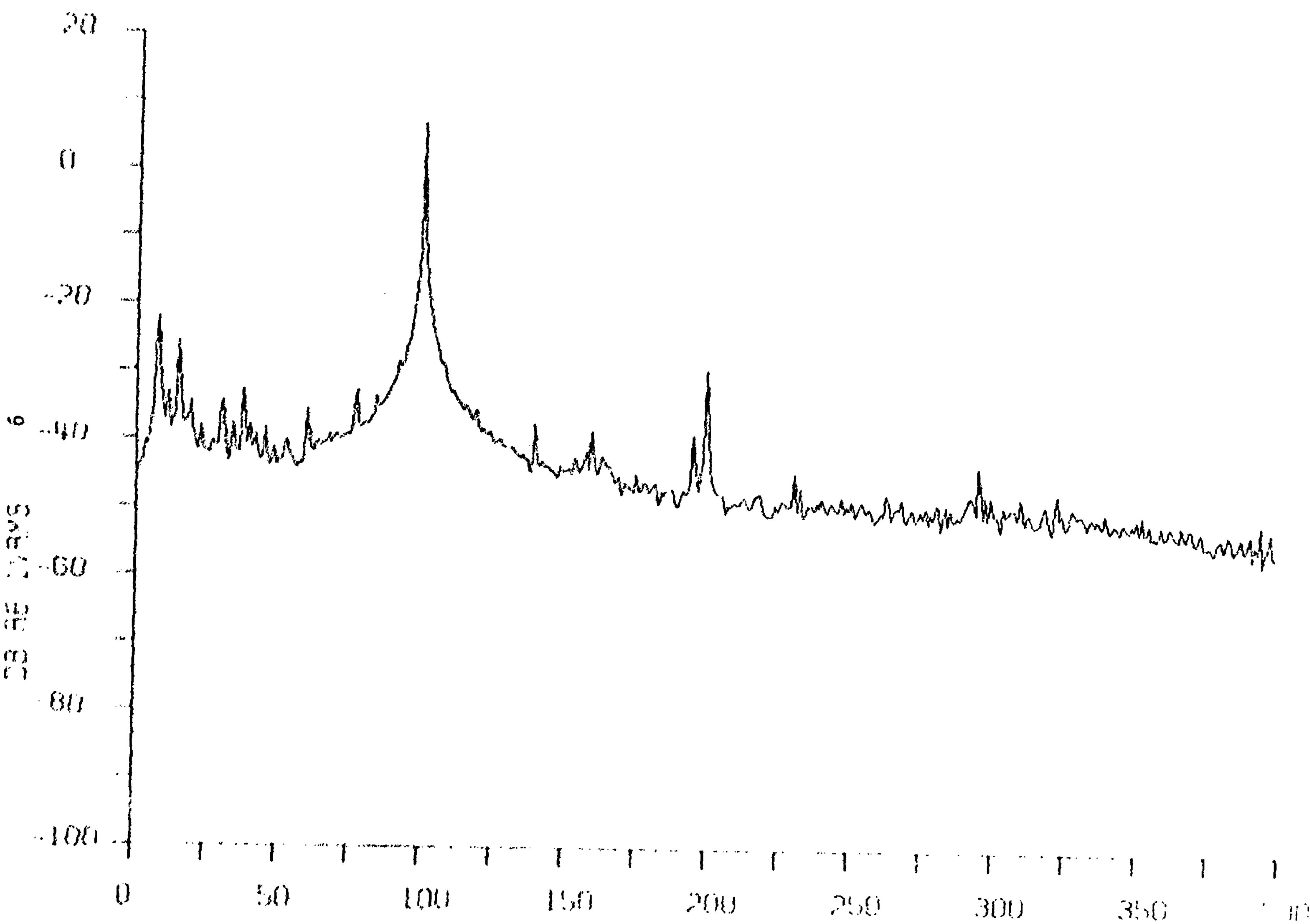
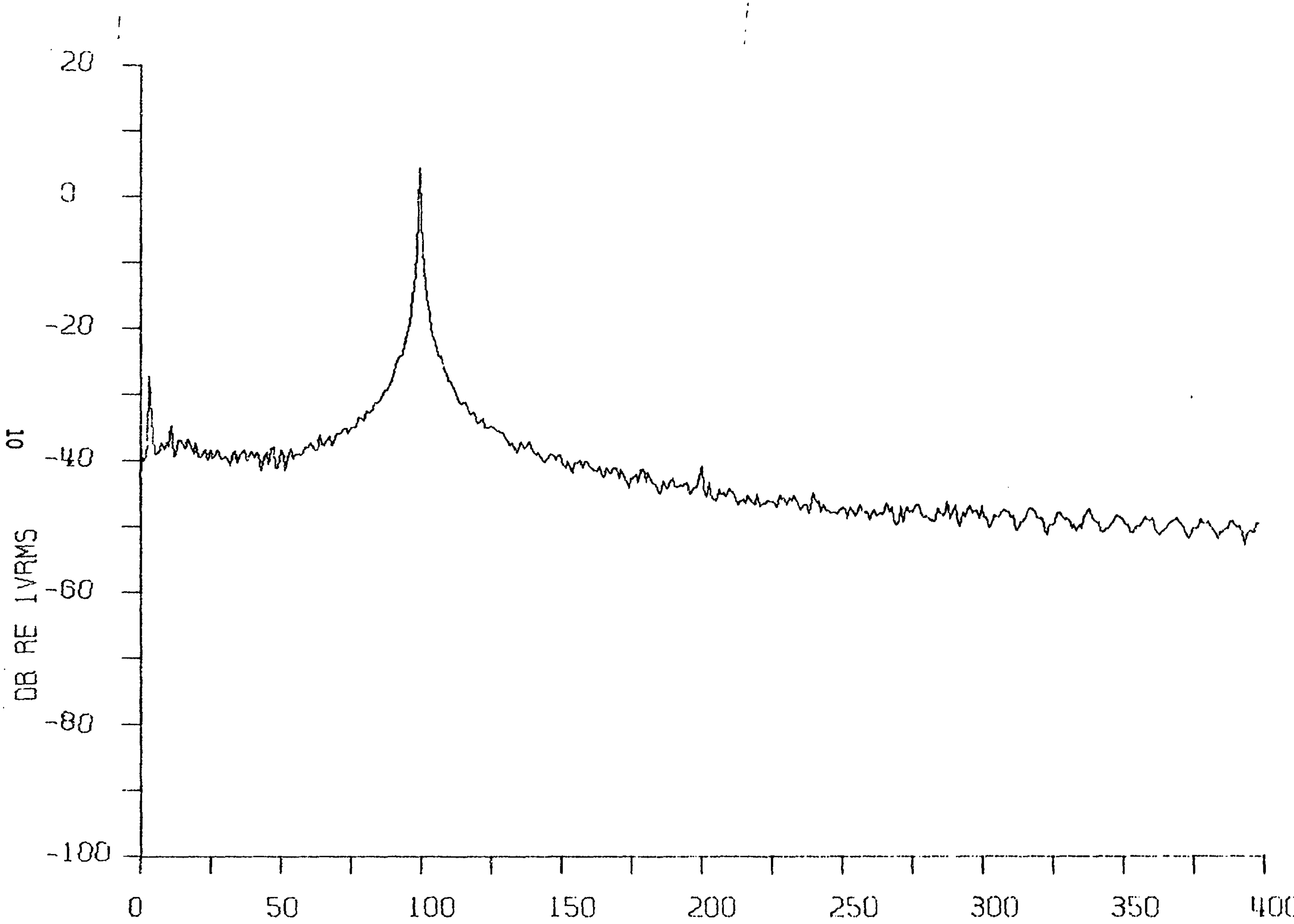


FIGURE 7. PAR SYSTEM 2 LAB CHANNEL 13 100HZ .3VRMS



The main impact of the problem is centered on those tests designed to measure harmonic distortion and frequency modulation noise. Due to the enhancement and introduction of harmonics by the pre-emphasis compensation network, it is difficult to draw direct conclusions about the presence and magnitude of harmonics and/or sidelobes in the spectra of the linear dynamic range data on system 1. The data recorded in the environmental chamber on system 2 is likewise contaminated.

C. Data Processing Techniques

1. Optimization Data

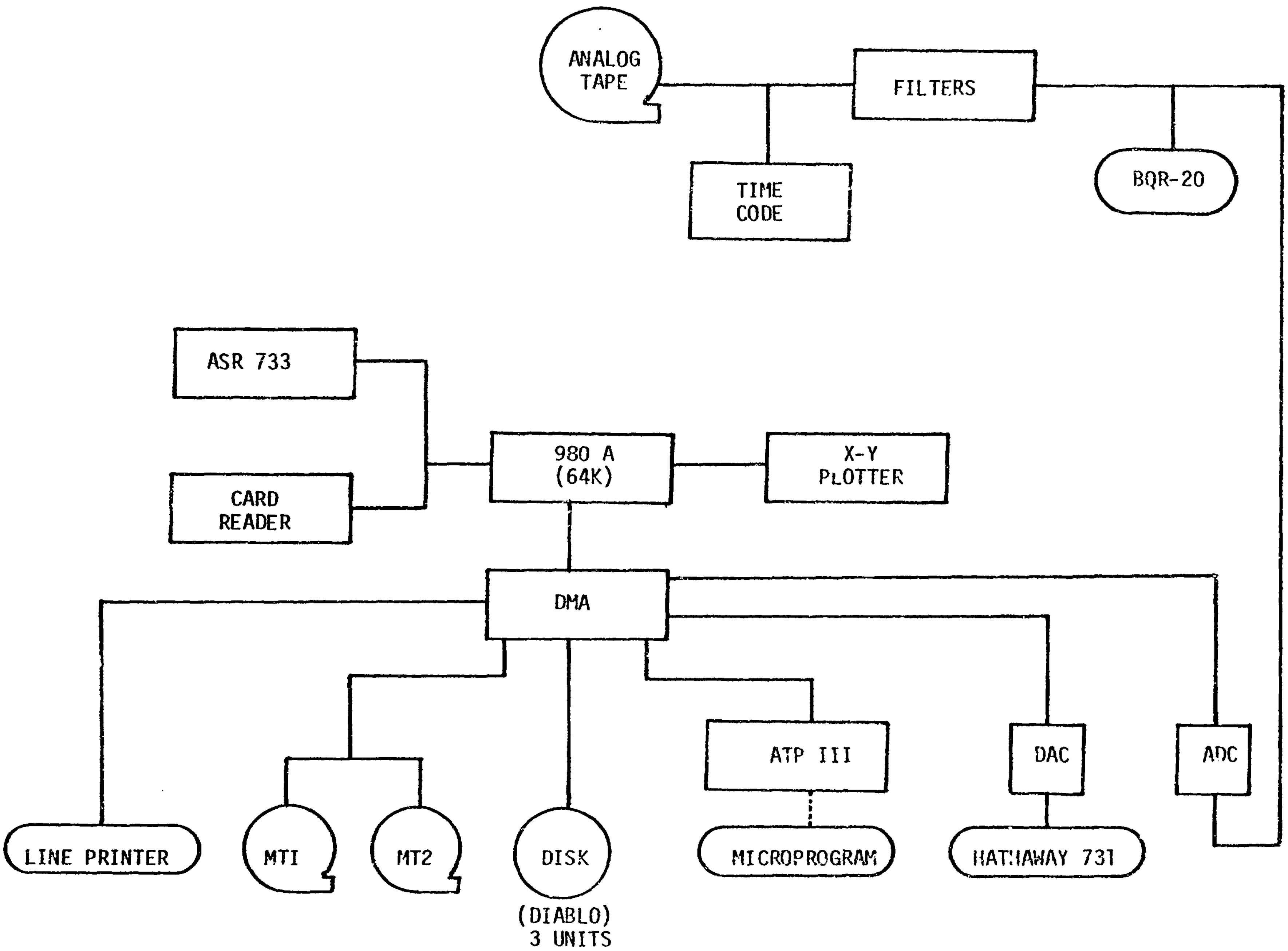
Optimization data was processed using a Hewlett Packard wave analyzer. Data tapes were reproduced at 1 7/8 ips (16 times real time), low pass filtered at 5000 Hz, (312 Hz real time) and input to the wave analyzer. The analyzer produced spectral plots with a resolution of 30 Hz (1.875 Hz real time) over the range 0 to 5 KHz. (0 to 312 Hz real time). These plots were then analyzed to determine the desired parameters.

2. Characterization Data

Characterization data sequences were analyzed with the TI980A computer system shown in Figure 8. Data tapes were reproduced at 1 7/8 ips and 30 ips. (16:1 and 256:1 increase in speed over real time respectively). At 1 7/8 ips data was low-pass filtered at 5000 Hz (312 Hz real time), sampled by an A/D converter at a rate of 14.2 KHz (888 Hz real time), and analyzed with a 1024 point FFT. Twenty second averages were computed to provide data in the 25 to 300 Hz range.

At 30 ips the data was low-pass filtered at 6900 Hz (27 Hz real time), sampled by the A/D converter at a rate of 14.2 KHz (55 Hz real time), and analyzed with a 256 point FFT. Twenty second averages were again computed to provide data in the 1.5 to 25 Hz range. All data was compensated for any signal gain introduced by the processing system.

FIGURE 8. ASW SIGNAL PROCESSING LAB



D. System Optimization

A sequence of signals was recorded under the simulated environmental conditions for the purpose of optimizing the PAR tape recording system.

1. Optimum Bias Level

Sine waves with frequencies of 6.25, 25, 100, 400, and 1000 Hz were recorded at .5 VRMS for bias levels of 2.0, 2.3, 2.5, 2.7, and 3.0 VRMS. Each channel was individually analyzed and evaluated for optimum frequency response and harmonic distortion. Figures 9 and 10 show the optimum bias levels for system 1 and system 2 respectively.

2. Maximum Record Level

With the bias levels set as determined in paragraph 1 above, a 100 Hz sine wave was recorded at levels of 0.5, 0.7, 0.9, 1.1, 1.3, and 1.5 VRMS. The maximum record level, defined as that level which produces third harmonic distortion of 1% (-40db), was determined to be 1 VRMS for both system 1 and system 2.

3. Optimum Reference Marker Level

The reference marker was recorded at levels of 0.7, 0.5, 0.3, and 0.1 VRMS mixed with white noise. Analysis of the reproduced signal using a bandpass filter revealed that the reference marker level is dependent on the amplitude of the reference tone. The optimum reference marker level was determined to be 2.5 times the amplitude of the reference tone, i.e. the ratio of the peak to peak amplitude of the reference marker to the reference tone is 2.5:1.

E. System Characterization

Several sequences of signals were recorded under both simulated environmental and laboratory conditions for the purpose of characterizing the PAR electronic systems in terms of performance. A discussion of the tests performed and the resulting characteristics of PAR systems 1 and 2 follows:

1. Linear Dynamic Range

a. Data Recorded

Single tones of 1.5 Hz, 3.0 Hz, 6.25 Hz, 12 Hz, 25 Hz, 100 Hz, 200 Hz, and 300 Hz were recorded on all channels at +3, 0, -6, -10, -20, -30, -40, and -50 dB re 1 VRMS. The gain in the PAR electronics was set to OdB.

FIGURE 9. PAR SYSTEM 1, OPTIMUM BIAS LEVELS

CHANNEL NUMBER	BIAS LEVEL (VRMS)
1	2.6
2	2.3
3	2.6
4	2.4
5	2.7
6	2.3
7	2.8
8	2.3
9	2.8
10	2.4
11	2.7
12	2.4
13	2.85

FIGURE 10. PAR SYSTEM 2, OPTIMUM BIAS LEVELS

CHANNEL NUMBER	BIAS LEVEL (VRMS)
1	2.7
2	2.7
3	2.7
4	2.7
5	2.6
6	2.7
7	2.7
8	2.7
9	2.7
10	2.7
11	2.7
12	2.7
13	2.5

b. System 1

Linear dynamic range data was analyzed at all frequencies on channels 2, 6, and 7. The 1.5 Hz, 3.0 Hz, 6.25 Hz, and 12 Hz tones were analyzed on channels 1, 3, 4, and 5. The 25 Hz, 100 Hz, 200 Hz, and 300 Hz tones were analyzed on channels 2, 6, and 7. All analyzed data was recorded in the environmental chamber and was contaminated by harmonics introduced by the pre-emphasis compensation circuit as discussed above. A summary of the dynamic range of each channel at each frequency is contained in Figure 11. Figures 12 through 15 graphically display the data for selected channels.

Careful examination of the plots and the summary table reveals that system 1 is linear over the range of -6 dB to -40 dB at all frequencies on all channels. The range is limited by a low signal to noise ratio at the -50 dB level making it difficult to accurately determine the existence of a tone. At input levels greater than -6 dB the linearity of the system seems to vary from channel to channel. However, by limiting input signal levels to fall in the range of -40 dB to -6 dB, linearity of the system will be assured over the entire range of frequencies from 1.5 Hz to 300 Hz.

c. System 2

Linear dynamic range data under environmental conditions was analyzed for all frequencies on channel 13. The 25 Hz, 100 Hz, 200 Hz, and 300 Hz tones were analyzed on channels 1-6; the 1.5 Hz, 3.0 Hz, 6.25 Hz, and 12 Hz tones were analyzed on channels 7-9, 11, and 12. Data recorded under laboratory conditions was analyzed at 6.25 Hz, 25 Hz, and 100 Hz on channels 2 and 13 for input levels of 0, -6, -10, -20, and -40 dB. A summary of the dynamic range of each channel at each frequency is contained in Figure 16 (environmental data) and Figure 17 (laboratory data). Figures 18 through 20 graphically display the data for selected channels.

Careful examination of these plots and the summary table reveals that system 2 is linear over the range of -40 dB to -6 dB. The limiting factors on the dynamic range of system 2 are the same as discussed previously for system 1.

FIGURE 11. SUMMARY OF LINEAR DYNAMIC RANGE DATA, SYSTEM 1

CHANNEL	1.5 Hz	3.0 Hz	6.25 Hz	12 Hz	25 Hz	100 Hz	200 Hz	300 Hz
1	0 to -50	0 to -50	-6 to -50	-6 to -50				
2	0 to -50	0 to -50	-6 to -50	-6 to -50	-6 to -50	0 to -50	0 to -50	0 to -50
3	0 to -50	0 to -50	-6 to -50	-6 to -50				
4	0 to -50	0 to -50	0 to -50	-6 to -50				
5	0 to -50	0 to -50	0 to -50	0 to -50				
6	0 to -50	0 to -50	-6 to -50	-6 to -50	-6 to -50	-6 to -50	-6 to -50	-6 to -50
7	-6 to -40	0 to -50	0 to -50	-6 to -50	-6 to -50	0 to -50	0 to -40	-6 to -50
8					0 to -50	0 to -50	0 to -50	0 to -40
9					-6 to -50	0 to -50	0 to -50	-6 to -50
10								
11					-6 to -50	0 to -50	0 to -50	-6 to -50
12					-6 to -50	0 to -50	0 to -50	-6 to -50
13					-6 to -50	0 to -50	-6 to -50	-6 to -40

FIGURE 12. SYSTEM 1 ENVIRONMENT CHANNEL 2

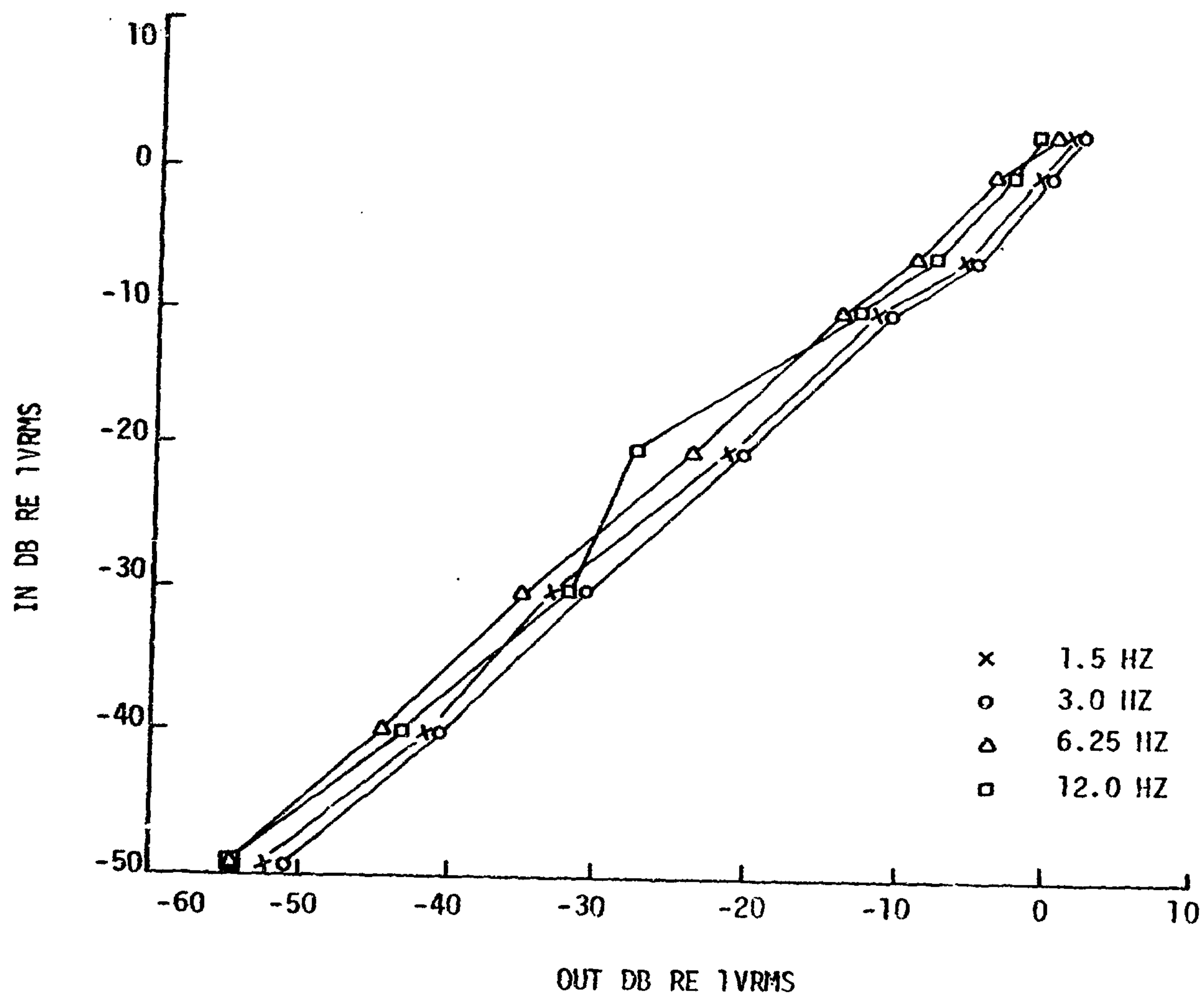


FIGURE 13. SYSTEM 1 ENVIRONMENT CHANNEL 2

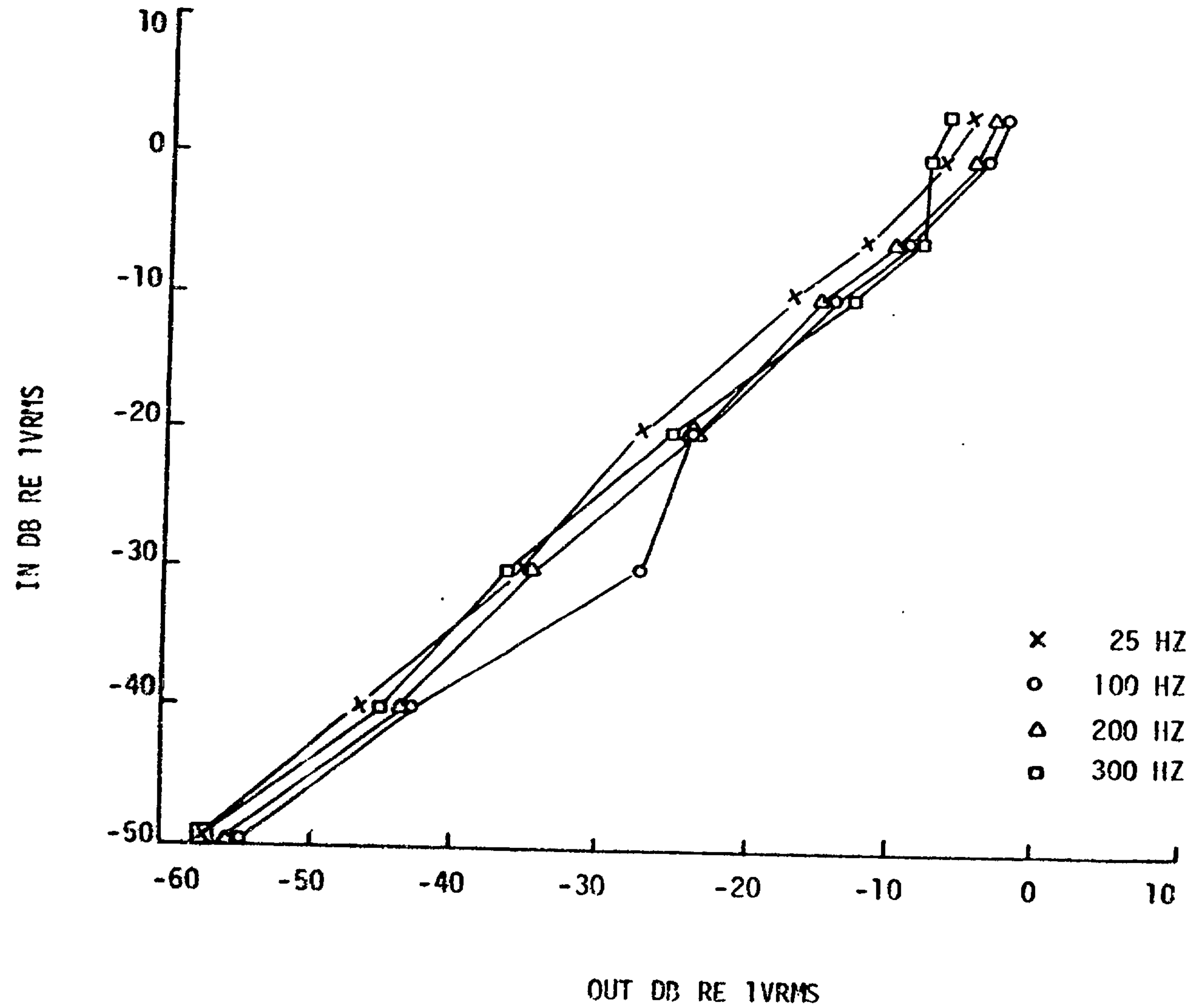


FIGURE 14. SYSTEM 1 ENVIRONMENT CHANNEL 7

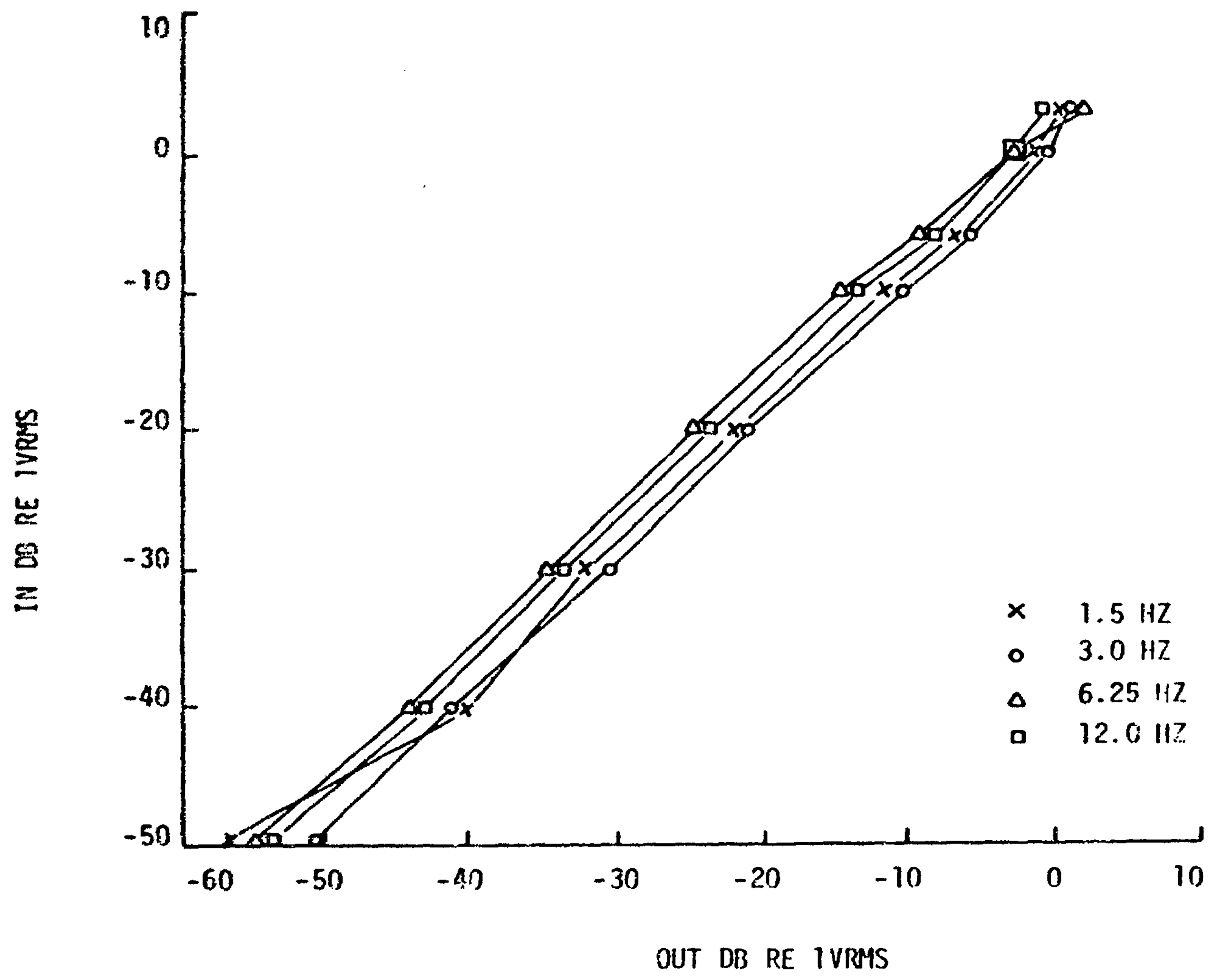


FIGURE 15. SYSTEM 1 ENVIRONMENT CHANNEL 7

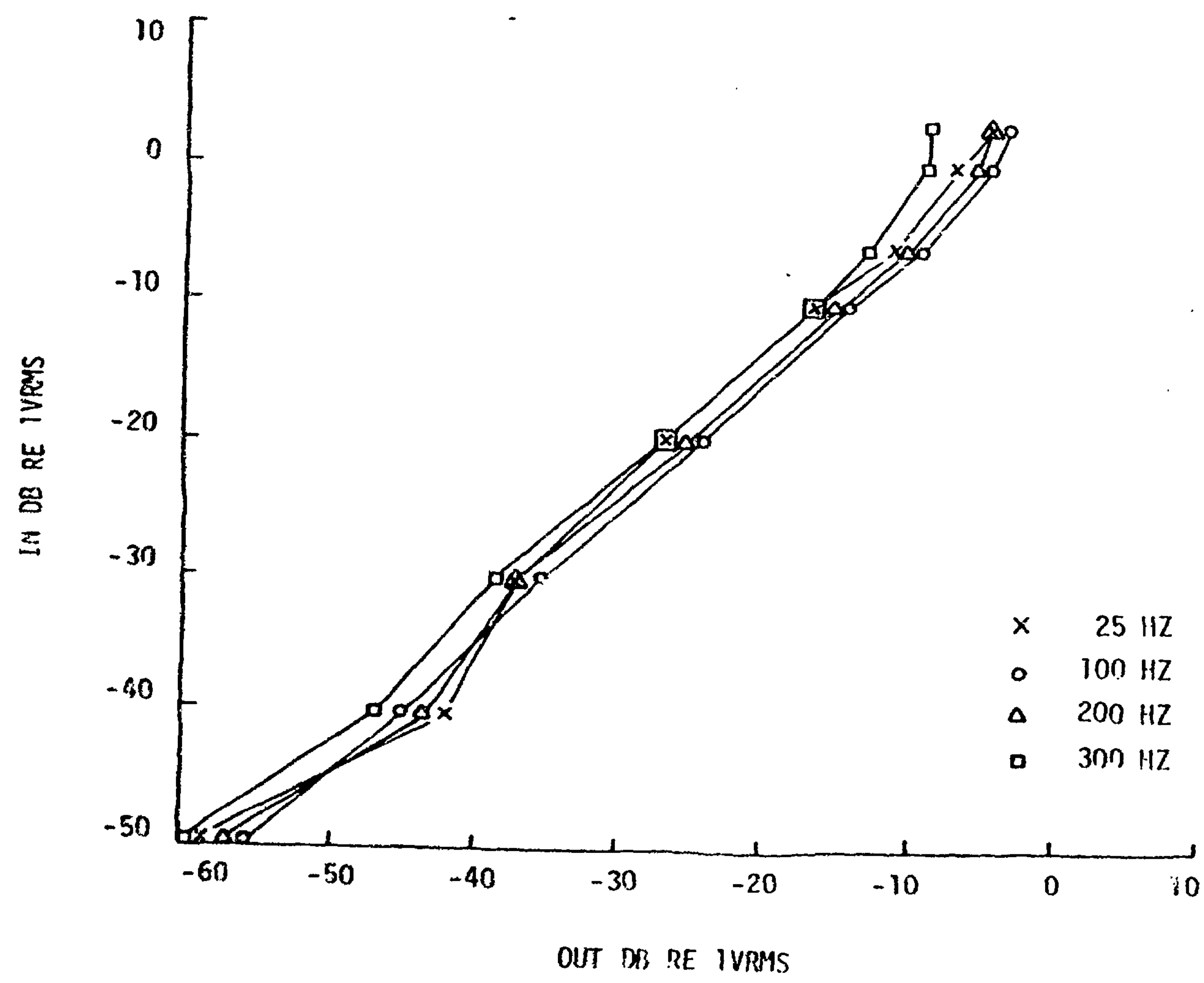


FIGURE 16. SUMMARY OF LINEAR DYNAMIC RANGE DATA SYSTEM 2 (ENVIRONMENT)

CHANNEL	1.5 Hz	3.0 Hz	6.25 Hz	12 Hz	25 Hz	100 Hz	200 Hz	300 Hz
1					-50 to +3	-50 to 0	-40 to -6	-40 to -6
2					-50 to +3	-50 to 0	-50 to 0	-50 to 0
3					-50 to +3	-50 to 0	-40 to +3	-40 to -6
4					-50 to +3	-50 to 0	-40 to +3	-50 to -6
5					-50 to +3	-40 to 0	-40 to 0	-40 to -6
6					-40 to +3	-50 to -6	-40 to +3	-40 to 0
7	-50 to 0	-40 to 0	-50 to 0	-50 to 0				
8	-50 to 0	-40 to 0	-50 to 0	-50 to 0				
9	-50 to 0	-40 to 0	-40 to 0	-50 to -6				
10								
11	-50 to +3	-40 to +3	-40 to 0	-40 to 0				
12	-50 to +3	-40 to +3	-40 to 0	-50 to +3				
13	-50 to 0	-40 to +3	-40 to 0	-50 to +3	-50 to +3	-50 to 0	-40 to 0	-50 to 0

FIGURE 17. SUMMARY OF LINEAR DYNAMIC RANGE DATA SYSTEM 2 (LABORATORY)

CHANNEL	6.25 Hz	25 Hz	100 Hz
7		-6 to -30	-6 to -30
13	-0 to -40	0 to -40	0 to -40

FIGURE 18. SYSTEM 2 ENVIRONMENT CHANNEL 13

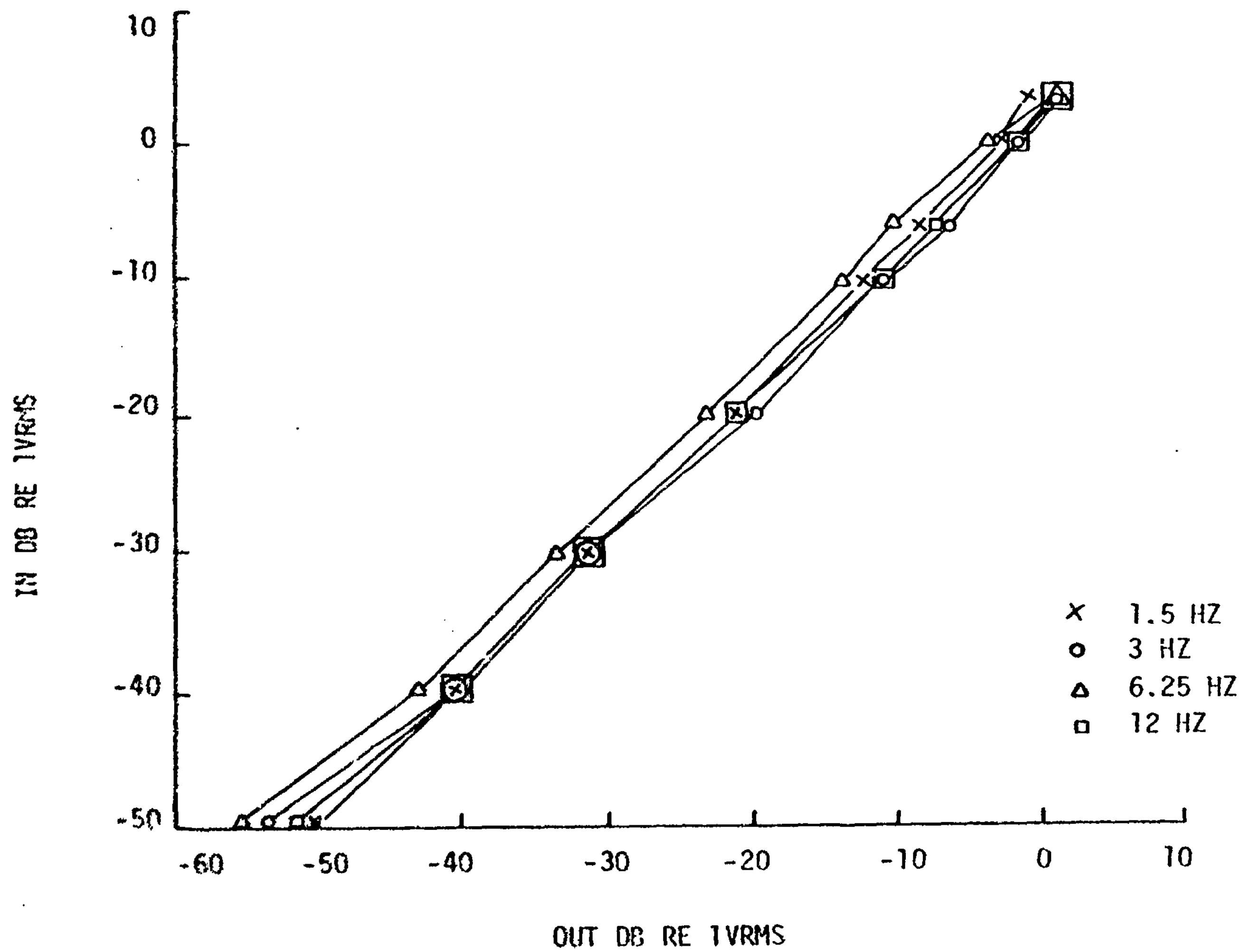


FIGURE 19. SYSTEM 2 ENVIRONMENT CHANNEL 13

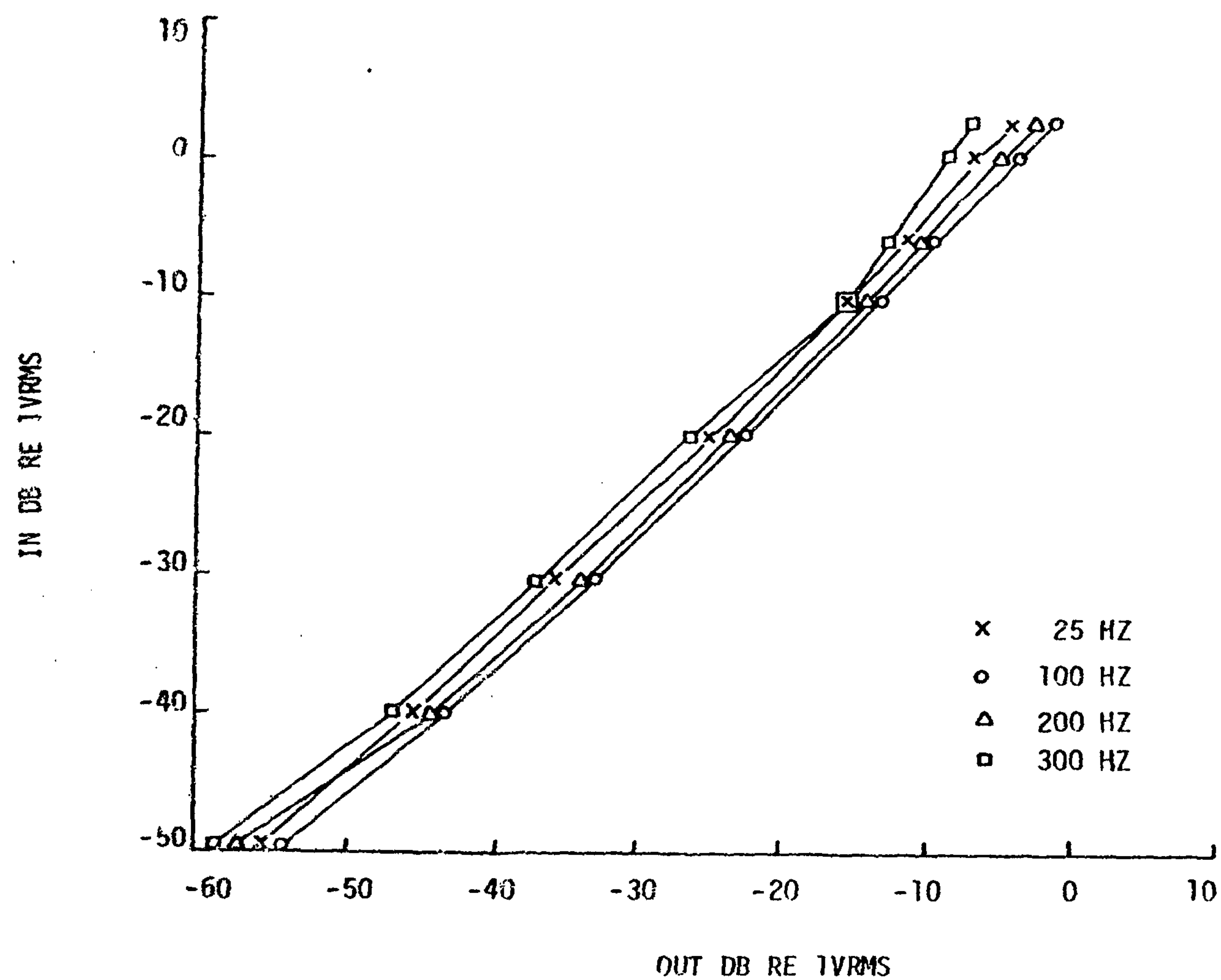
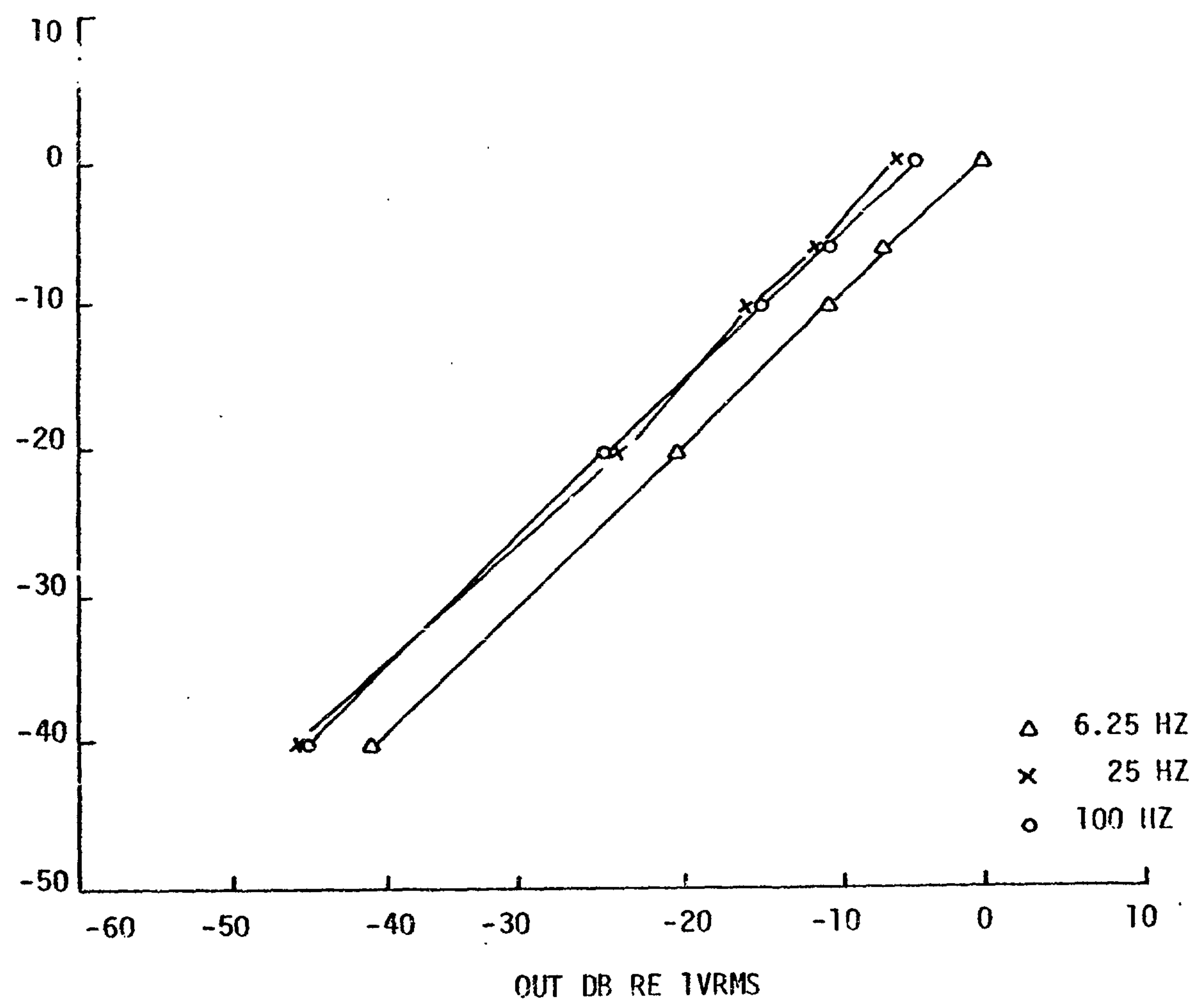


FIGURE 20. SYSTEM 2 LABORATORY CHANNEL 13



The dynamic range of laboratory recorded data is also -40 dB to -6 dB. A comparison of data recorded under laboratory conditions with that recorded under environmental conditions (Figures 16 and 17) reveals that dynamic range is not a function of temperature.

2. Gain Linearity

a. Data Recorded

The linearity of the gain ranging electronics was determined by recording a 50 Hz tone on all channels simultaneously. Starting at an amplitude of .5 VRMS (-6 dB) and a gain of 0 dB in the PAR electronics, the signal amplitude was decreased in 6 dB step, while simultaneously increasing the gain in 6 dB steps.

b. System 1

Figures 21 through 28 show the spectrum of the 50 Hz tone at each gain state for channel 6. The other channels produced similar results and also displayed the enhanced harmonics due to the pre-emphasis compensation problem described above.

Figure 29 lists the processed signal level at each gain state for channel 6. The table and plots show that the gain ranging electronics on channel 6 of PAR system 1 produced a 6 $\pm$ 0.5 dB gain step between adjacent states. The other channels of system 1 showed similar increments between adjacent states.

c. System 2

Figures 30 through 37 show the spectra of the 50 Hz tone recorded on channel 13 under laboratory conditions. The signal strength at each gain state is tabulated in Figure 29. This data shows that there is a 6 $\pm$ 0.5 dB increment between adjacent gain states on channel 13. Similar results were obtained for all the other channels under laboratory conditions.

Since no significant differences were noted between environmental and laboratory data, it can be concluded that the gains of the data amplifiers are independent of temperature.

FIGURE 21. PAR SYSTEM 1 CHANNEL 6 50HZ 0.5V GS = 0

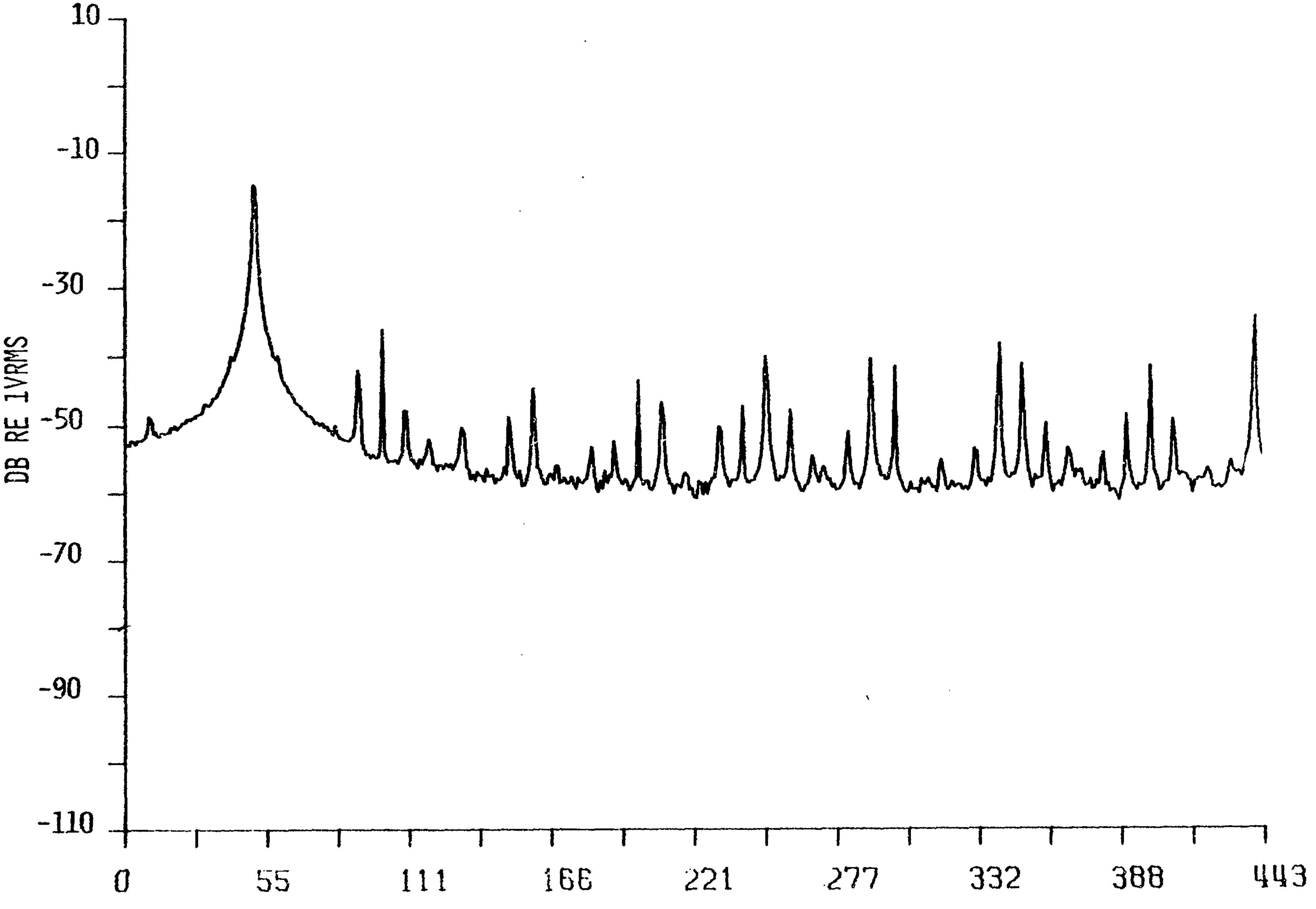


FIGURE 22. PAR SYSTEMS 1 CHANNEL 6 50HZ 0.25V GS = 1

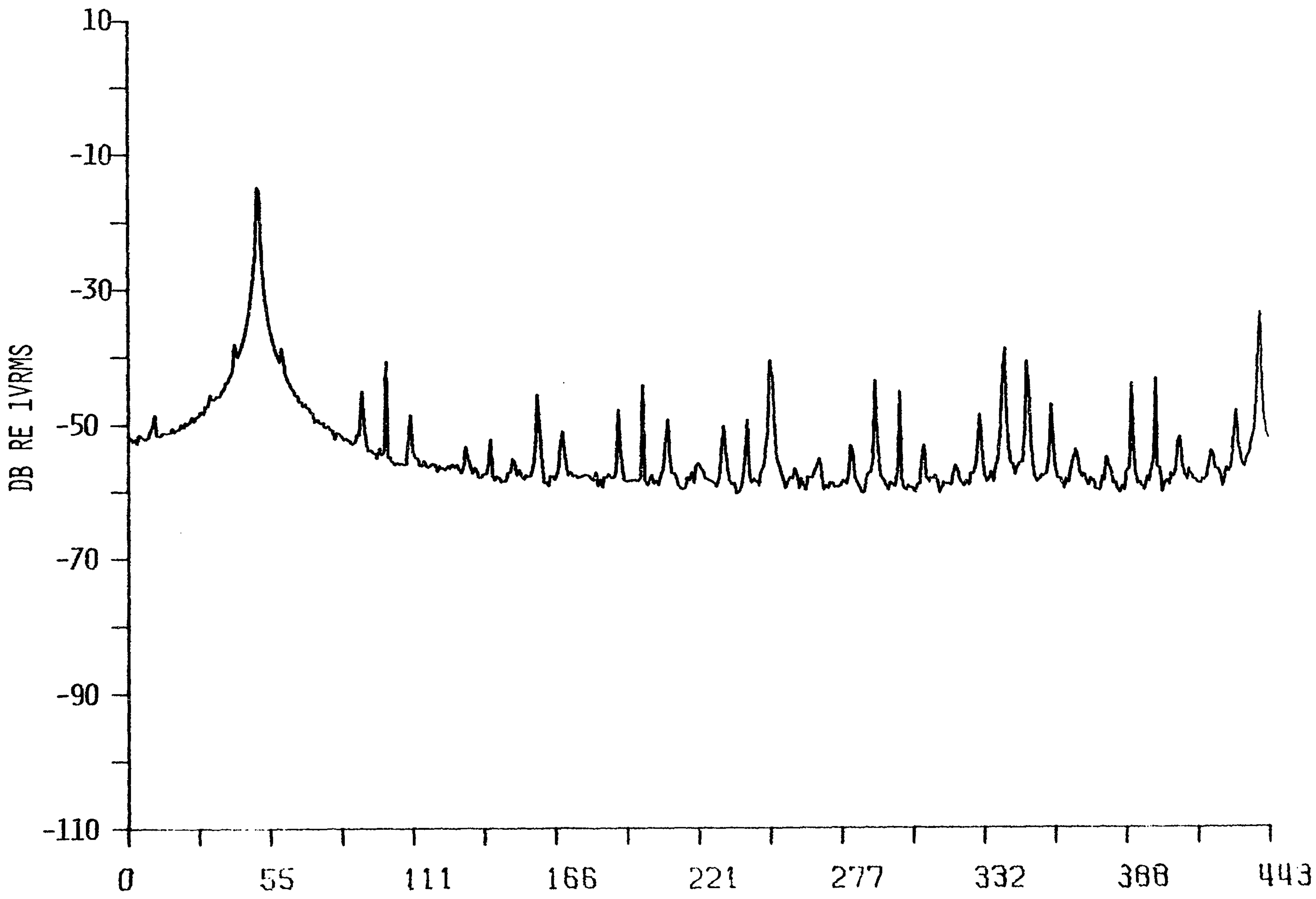


FIGURE 23. PAR SYSTEMS 1 CHANNEL 6 50HZ 0.126V GS = 2

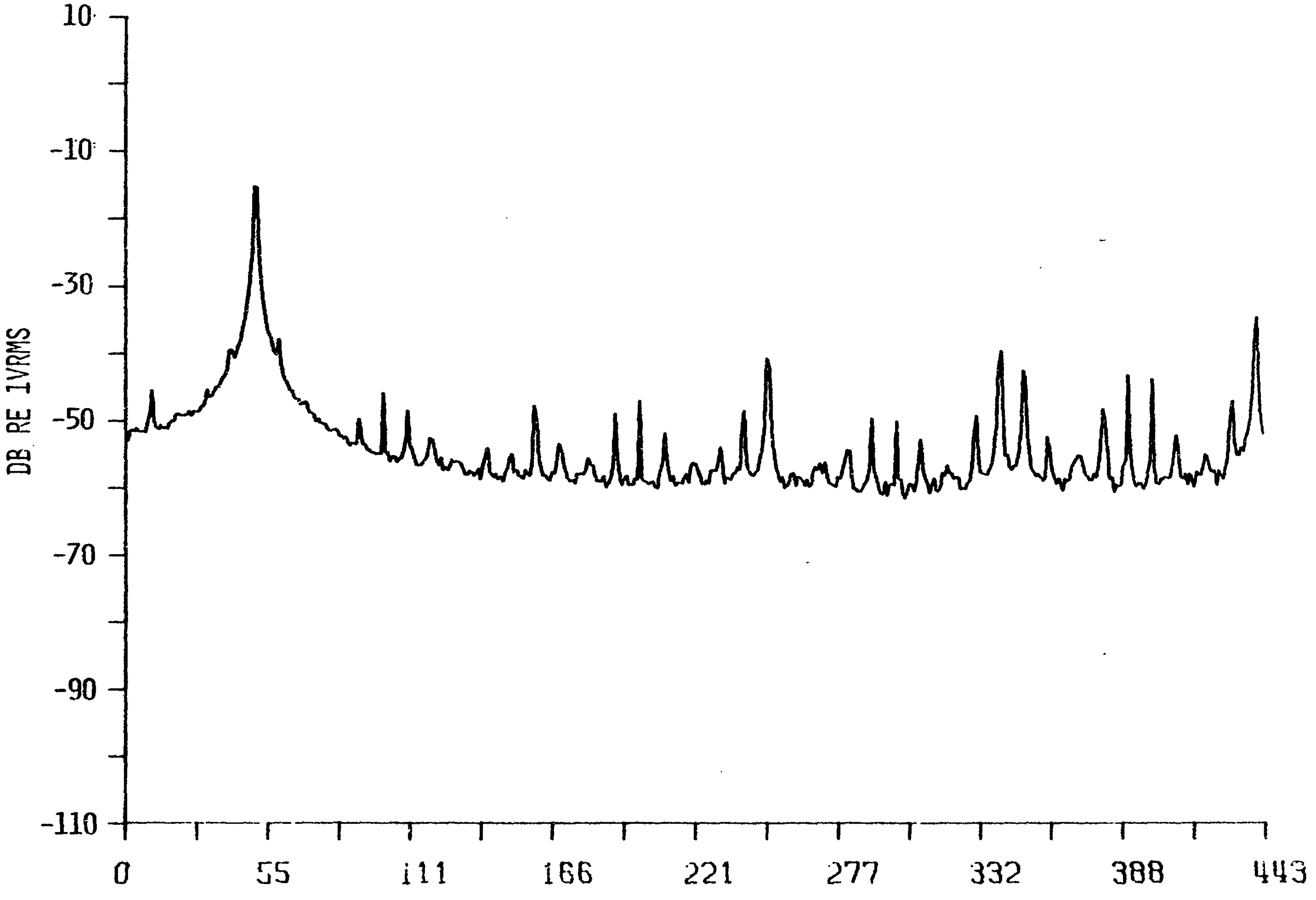


FIGURE 24. PAR SYSTEMS 1 CHANNEL 6 50HZ 0.063V GS = 3

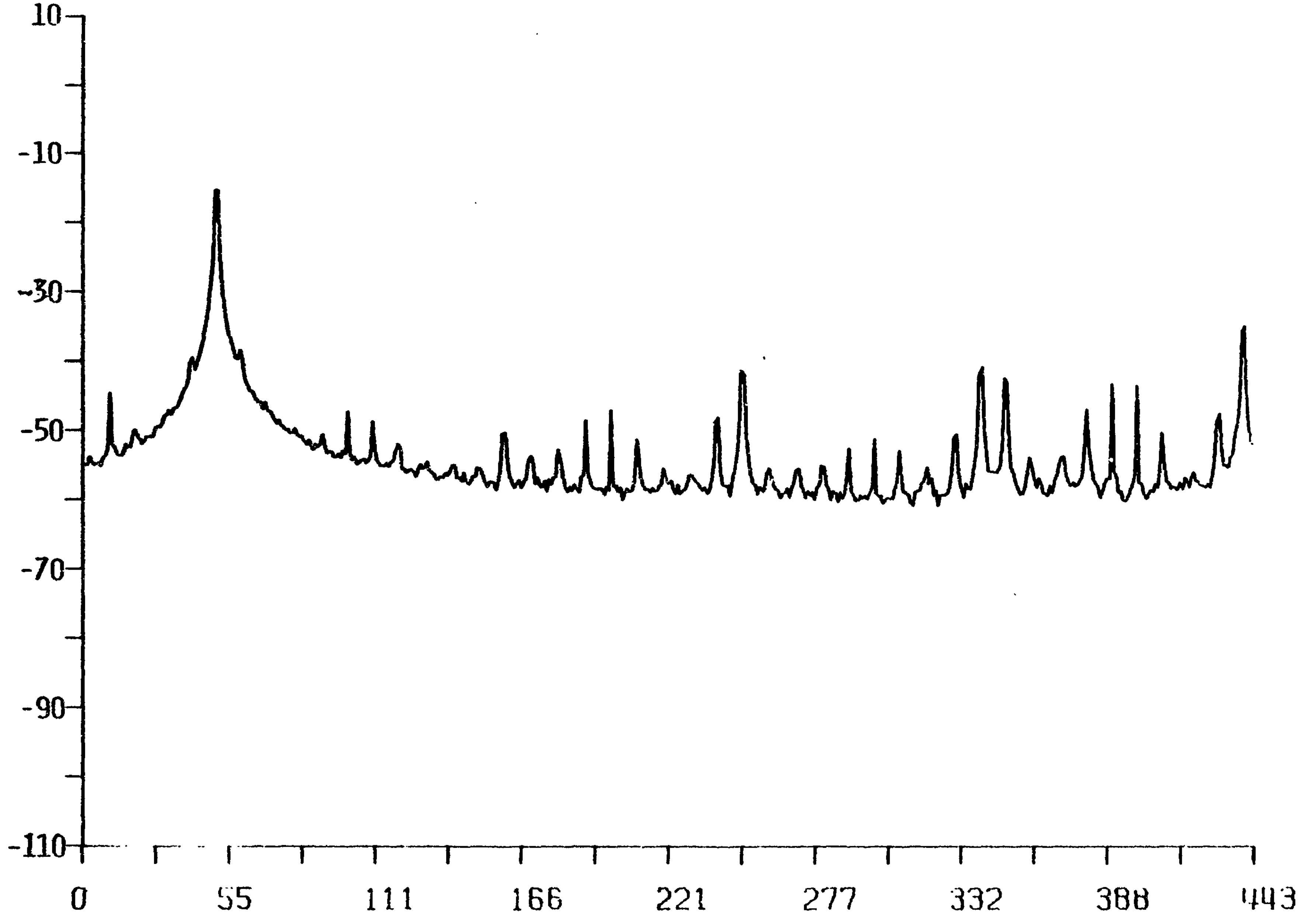


FIGURE 25. PAR SYSTEM 1 CHANNEL 6 50HZ 0.32V GS = 4

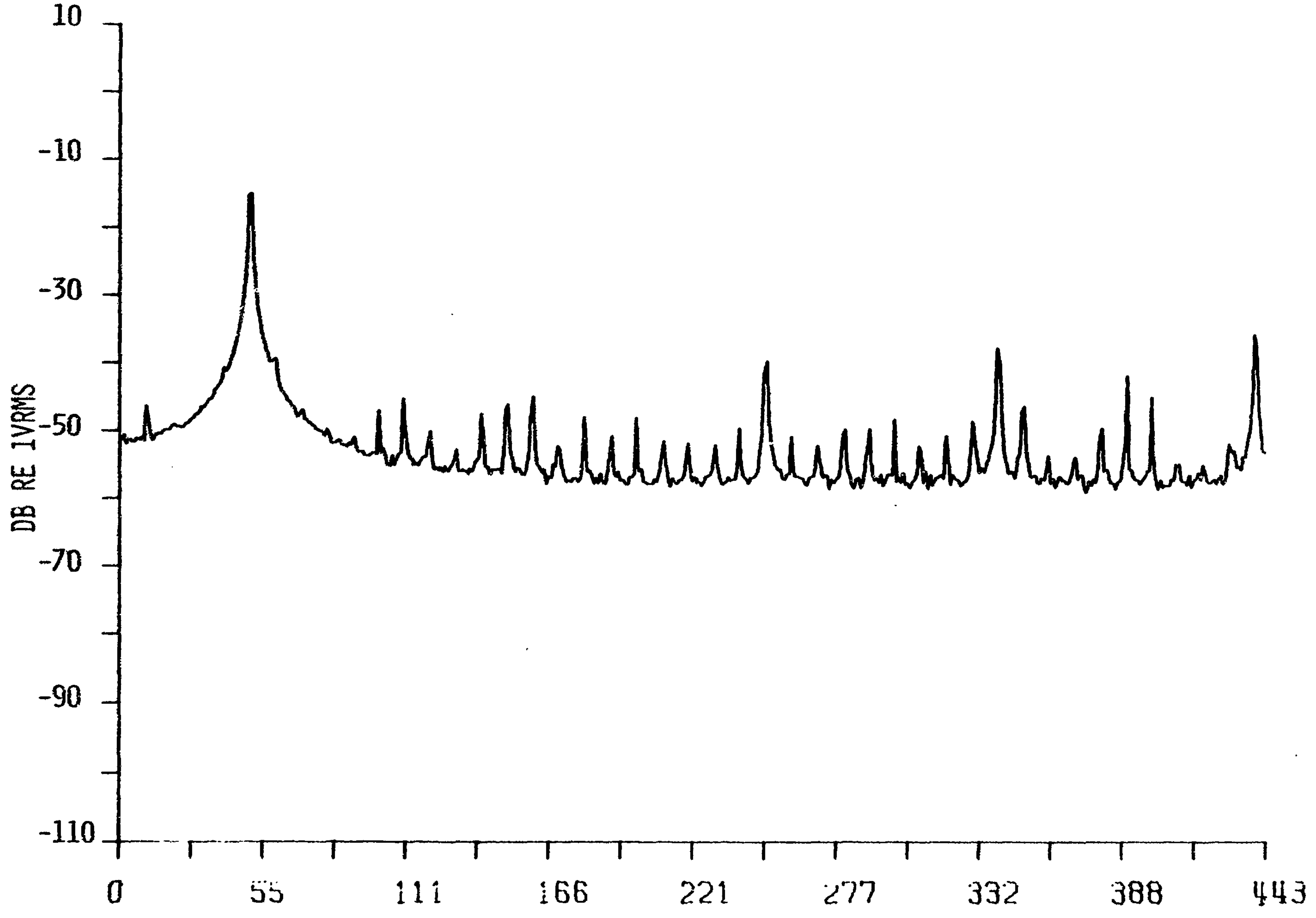


FIGURE 26. PAR SYSTEM CHANNEL 6 50HZ 0.158V GS = 5

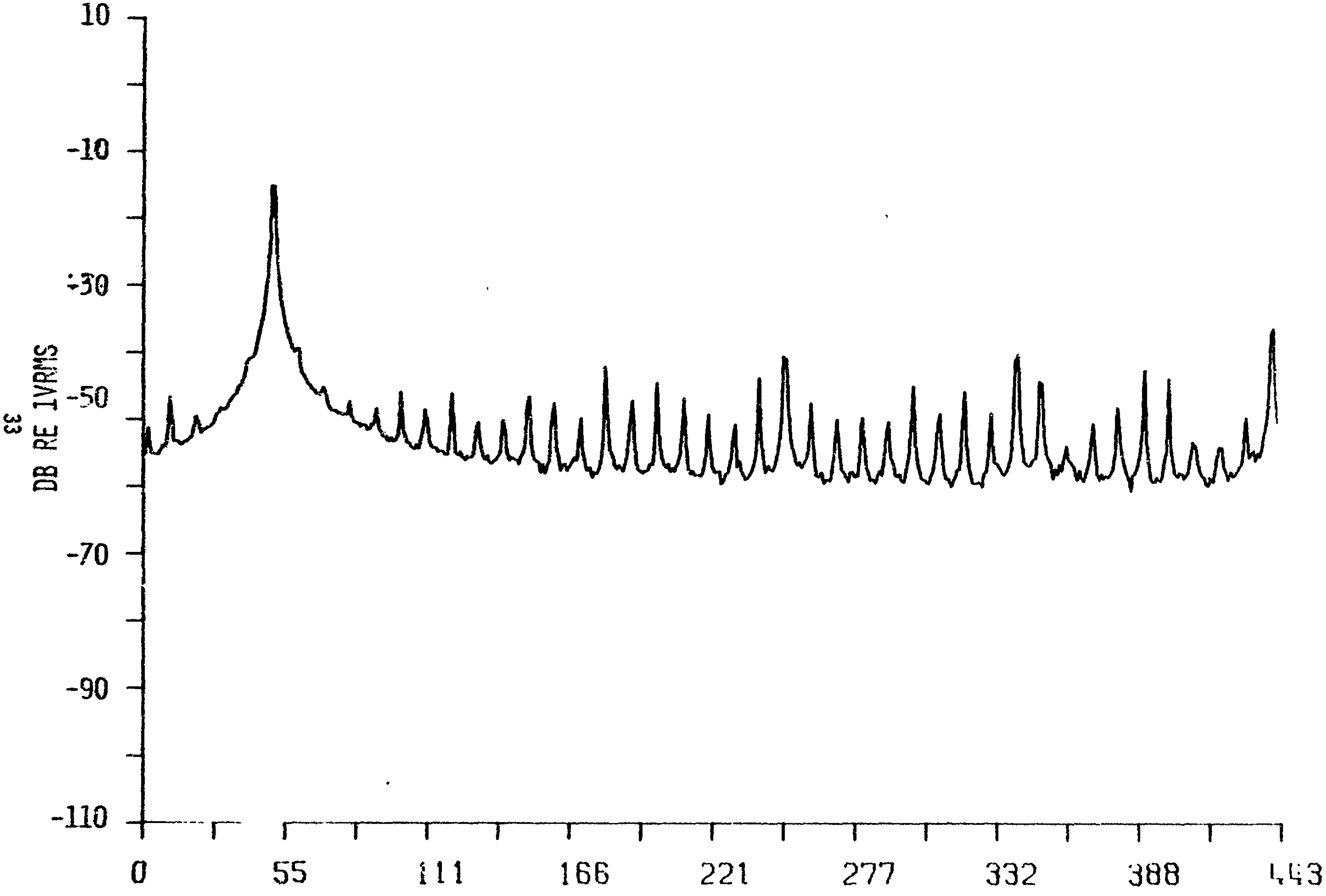


FIGURE 27. PAR SYSTEM 1 CHANNEL 6 50HZ 0.0078V GS = 6

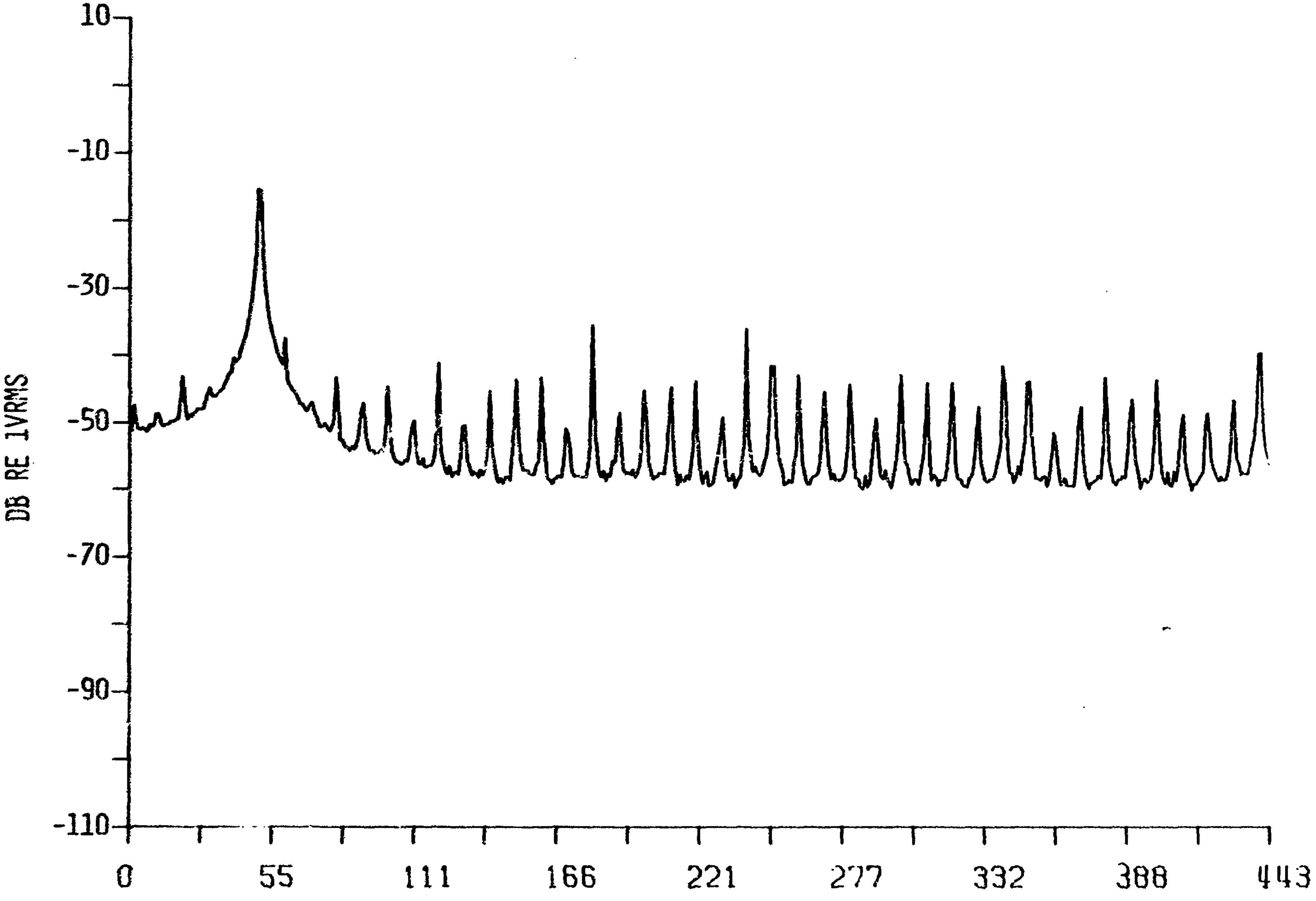


FIGURE 28. PAR SYSTEMS 1 CHANNEL 6 50HZ 0.004V GS= 7

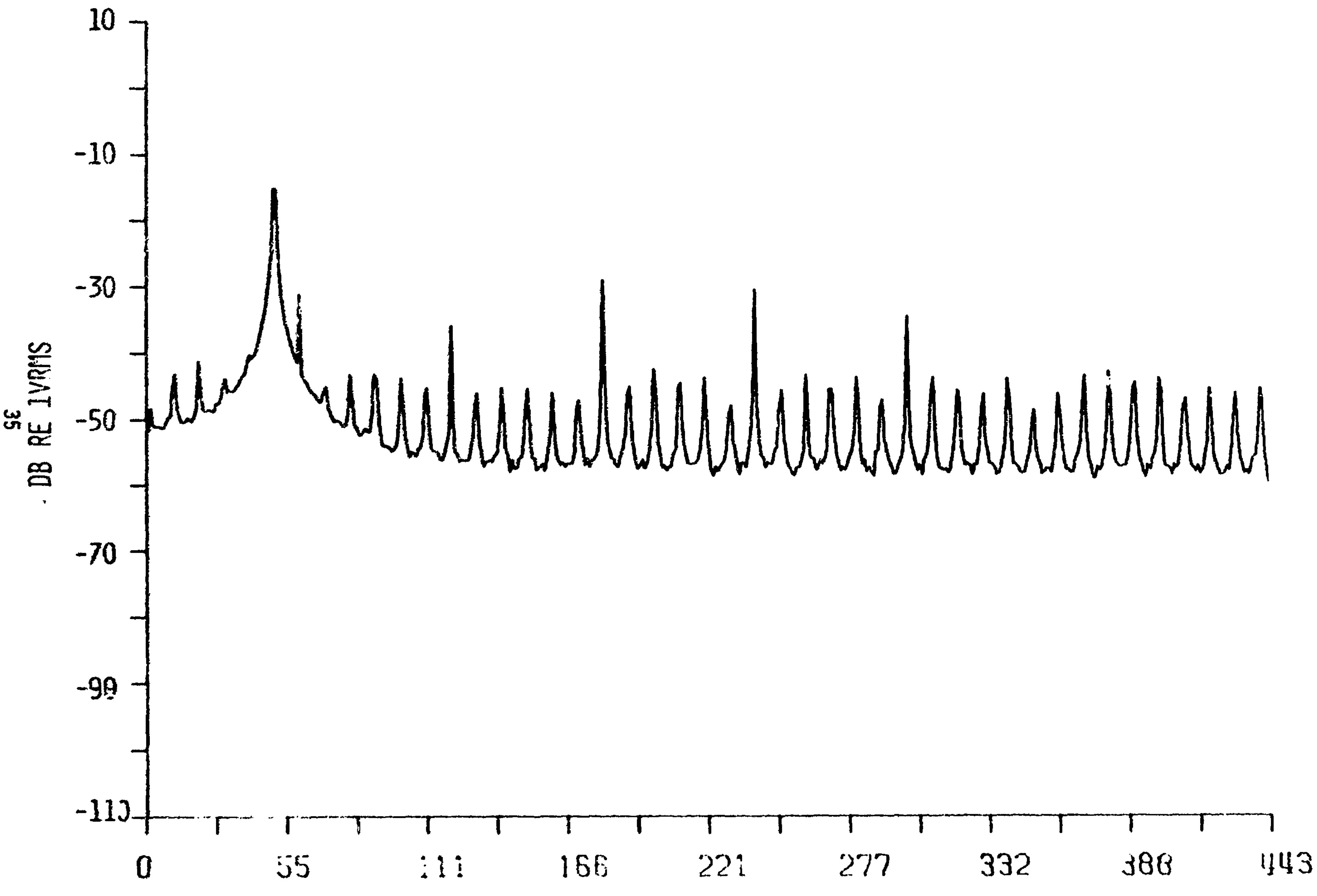


FIGURE 29. GAIN LINEARITY

INPUT	GAIN STATE	SYSTEM 1 ENVIRONMENT CHANNEL 6	SYSTEM 2 LABORATORY CHANNEL 3
-6 dB	0	-12.3 dB	-11.0 dB
-12	1	-12.5	-10.5
-18	2	-12.6	-10.7
-24	3	-12.8	-11.0
-30	4	-12.5	-10.7
-36	5	-12.6	-10.7
-42	6	-12.8	-11.5
-48	7	-12.5	-11.3

FIGURE 30. PAR SYSTEM 2 LAB CHANNEL 13 50HZ 0.5V GS = 0

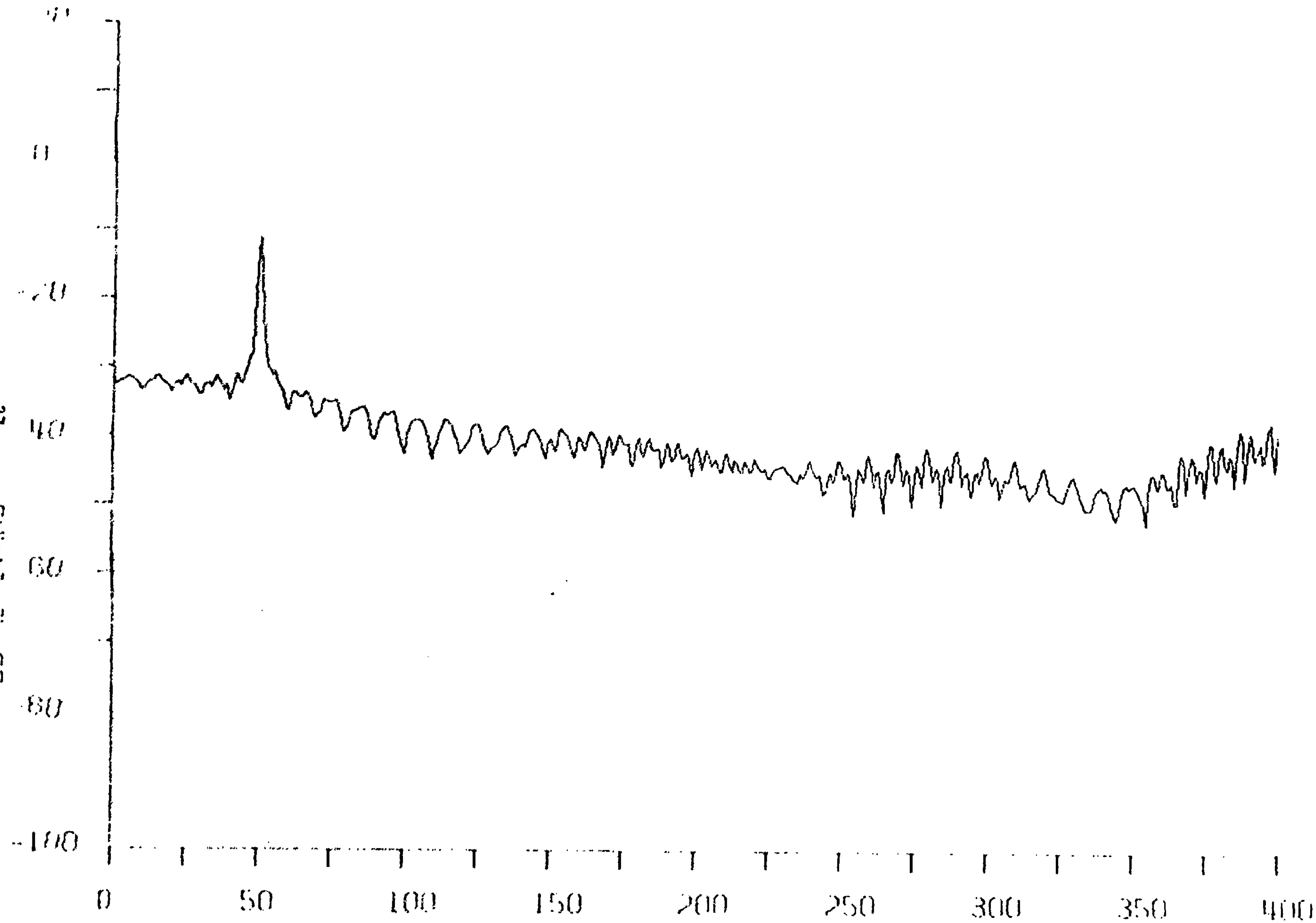


FIGURE 31. PAR SYSTEM 2 LAB CHANNEL 13 50HZ .25V GS = 1

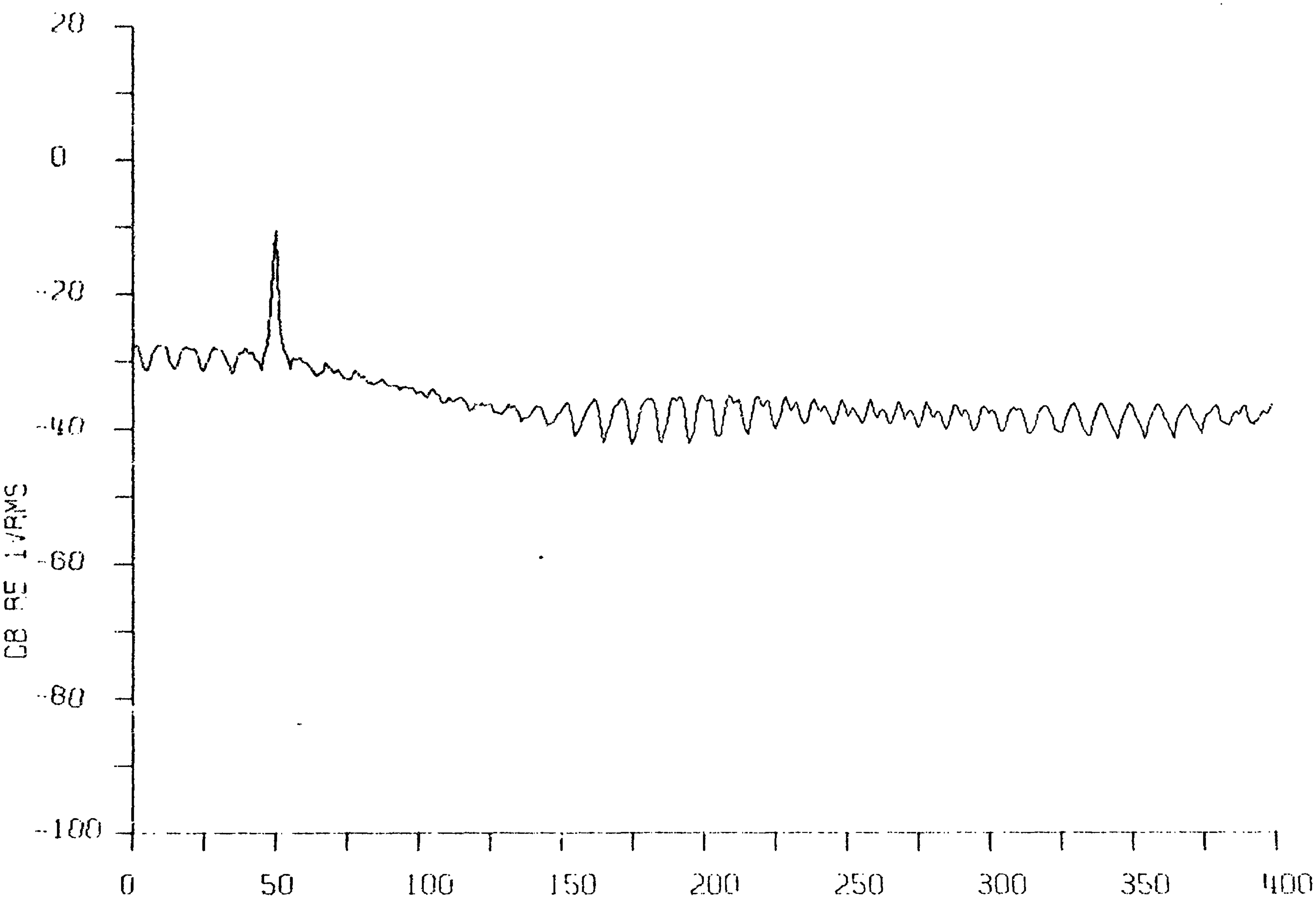


FIGURE 32. PAR SYSTEM 2 LAB CHANNEL 13 50HZ 0.126V GS = 2

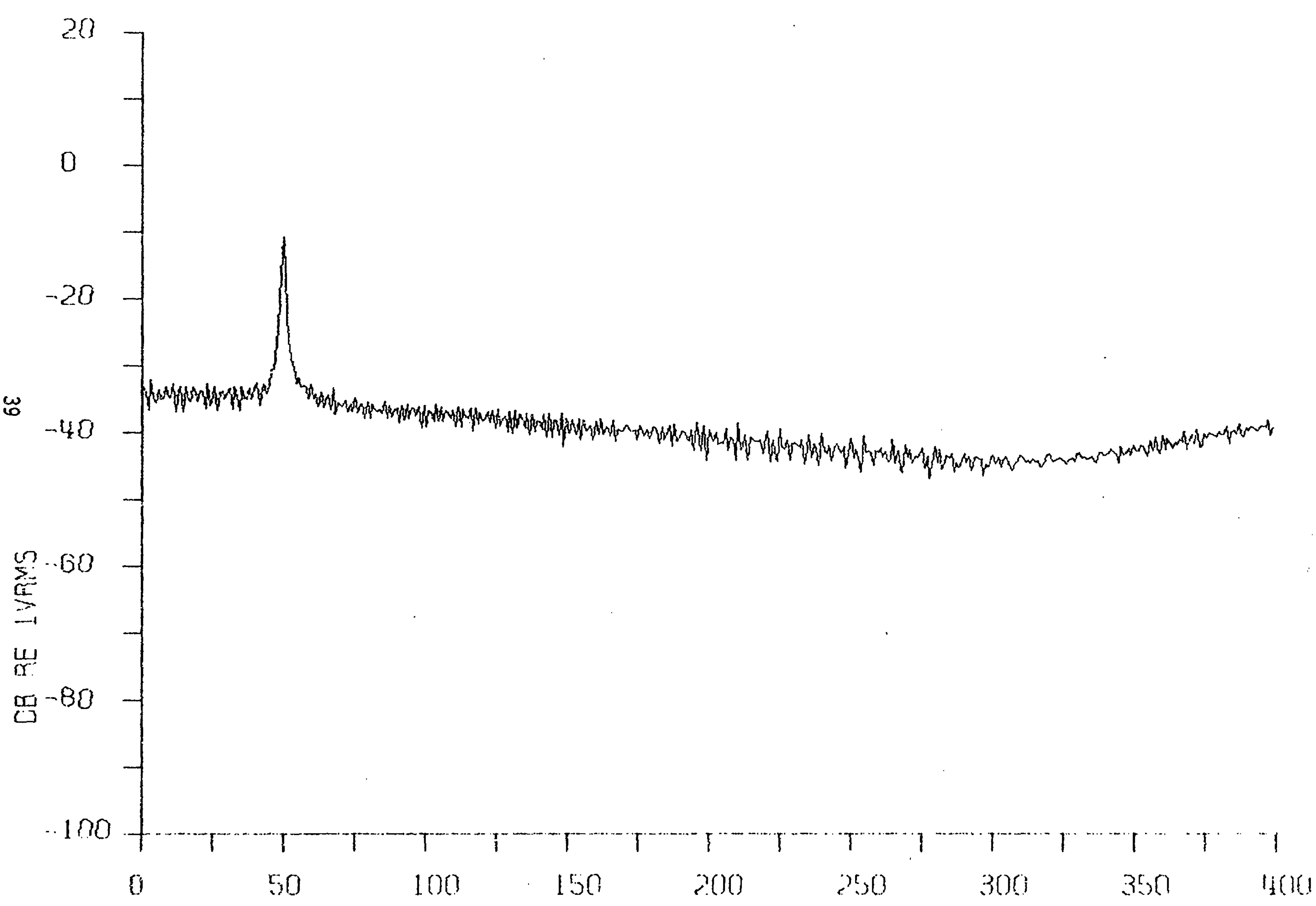


FIGURE 33. PAR SYSTEM 2 LAB CHANNEL 13 50HZ .063V GS = 3

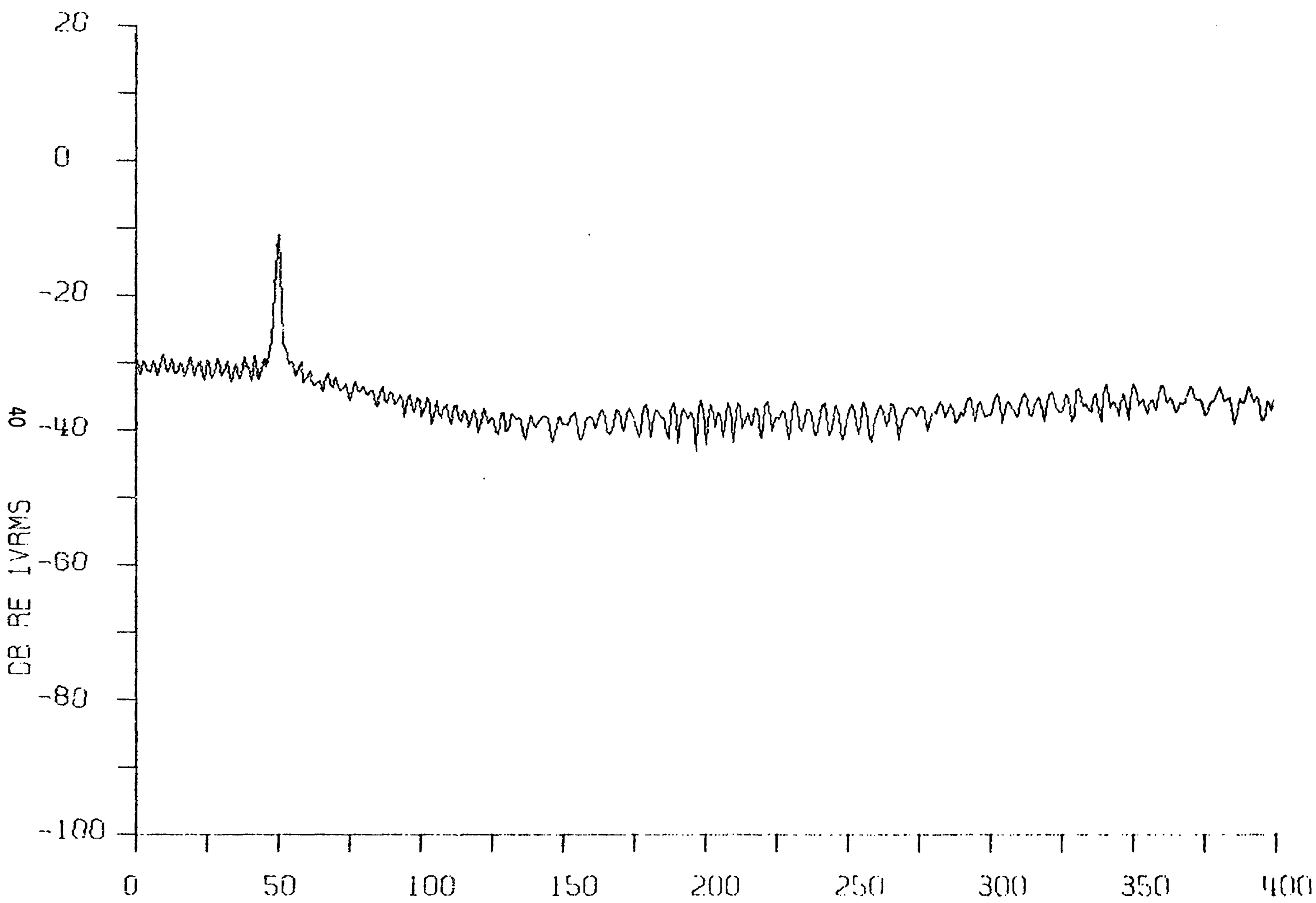


FIGURE 34. PAR SYSTEM 2 LAB CHANNEL 13 50HZ .032V GS = 4

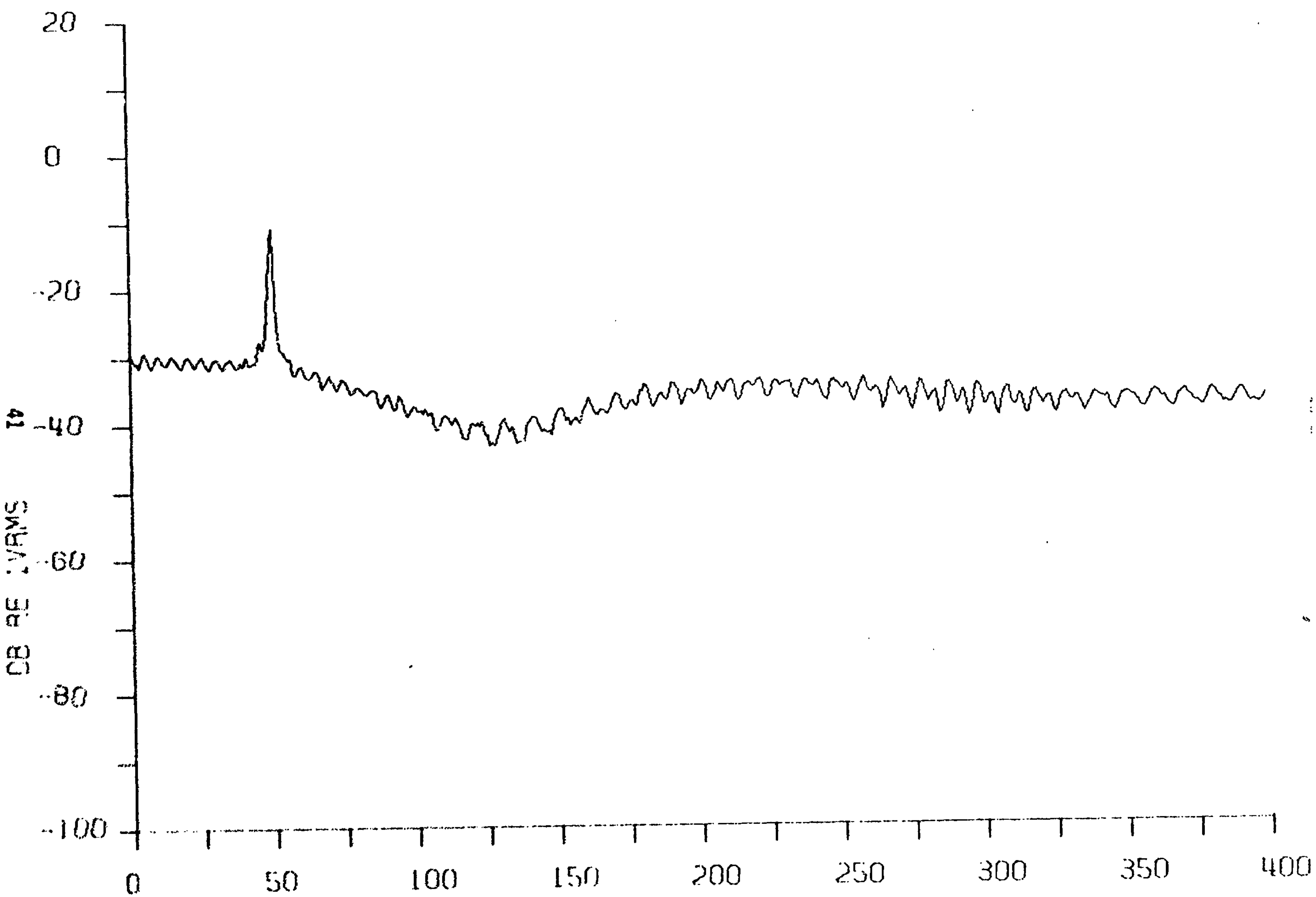


FIGURE 35. PAR SYSTEM 2 LAB CHANNEL 13 50HZ .0158V GS = 5

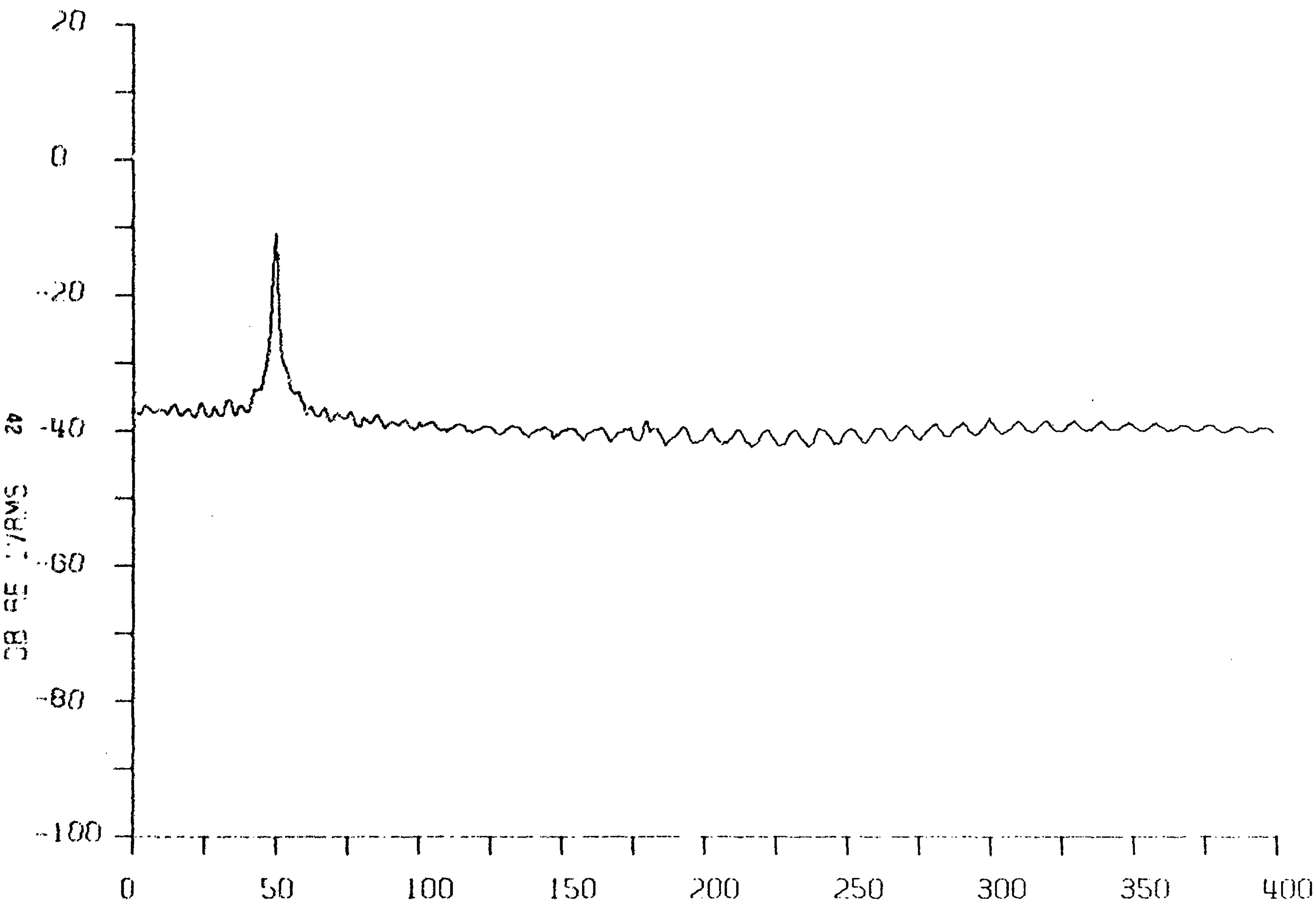


FIGURE 36. PAR SYSTEM 2 LAB CHANNEL 13 50HZ .0079 GS = 6

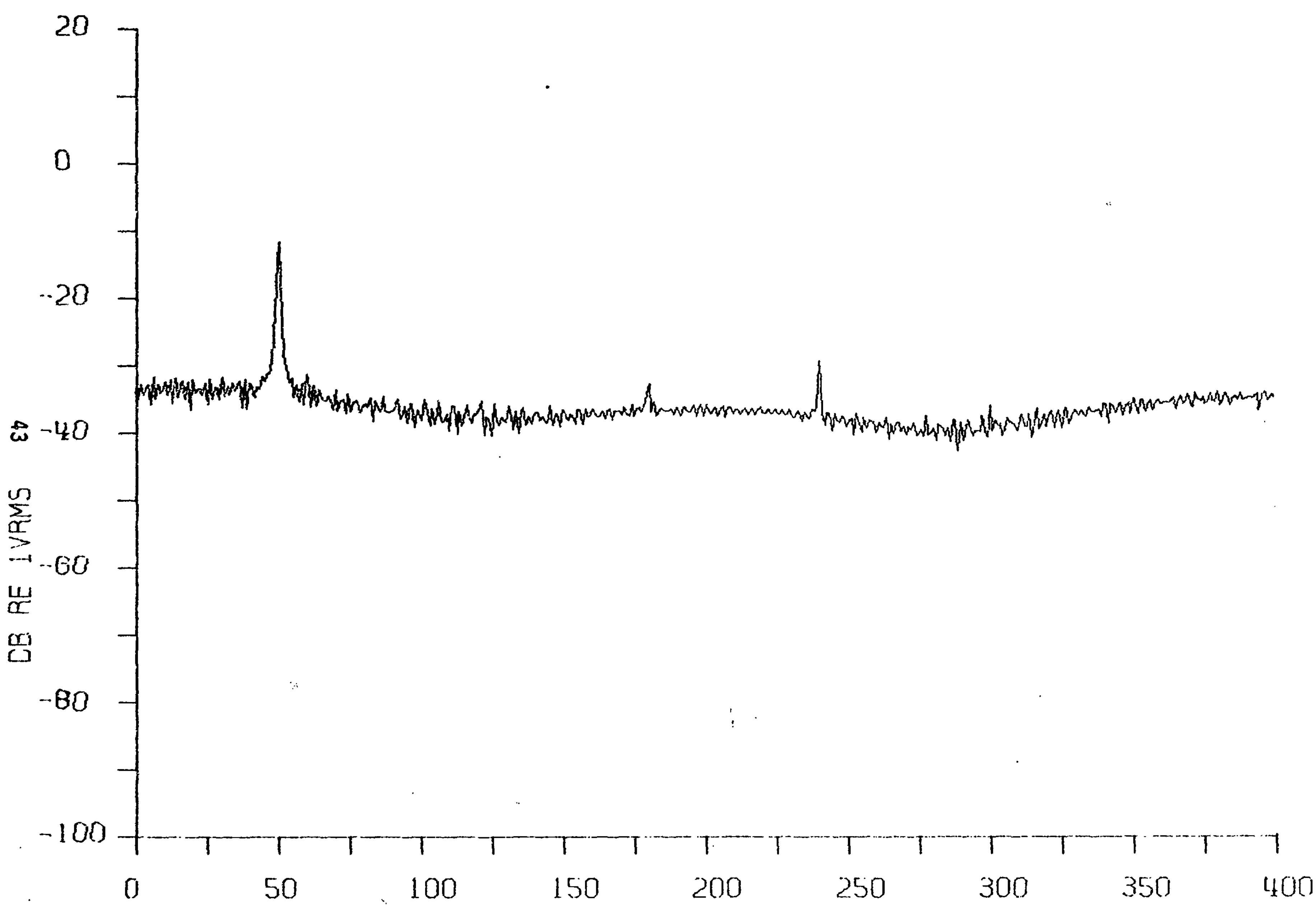
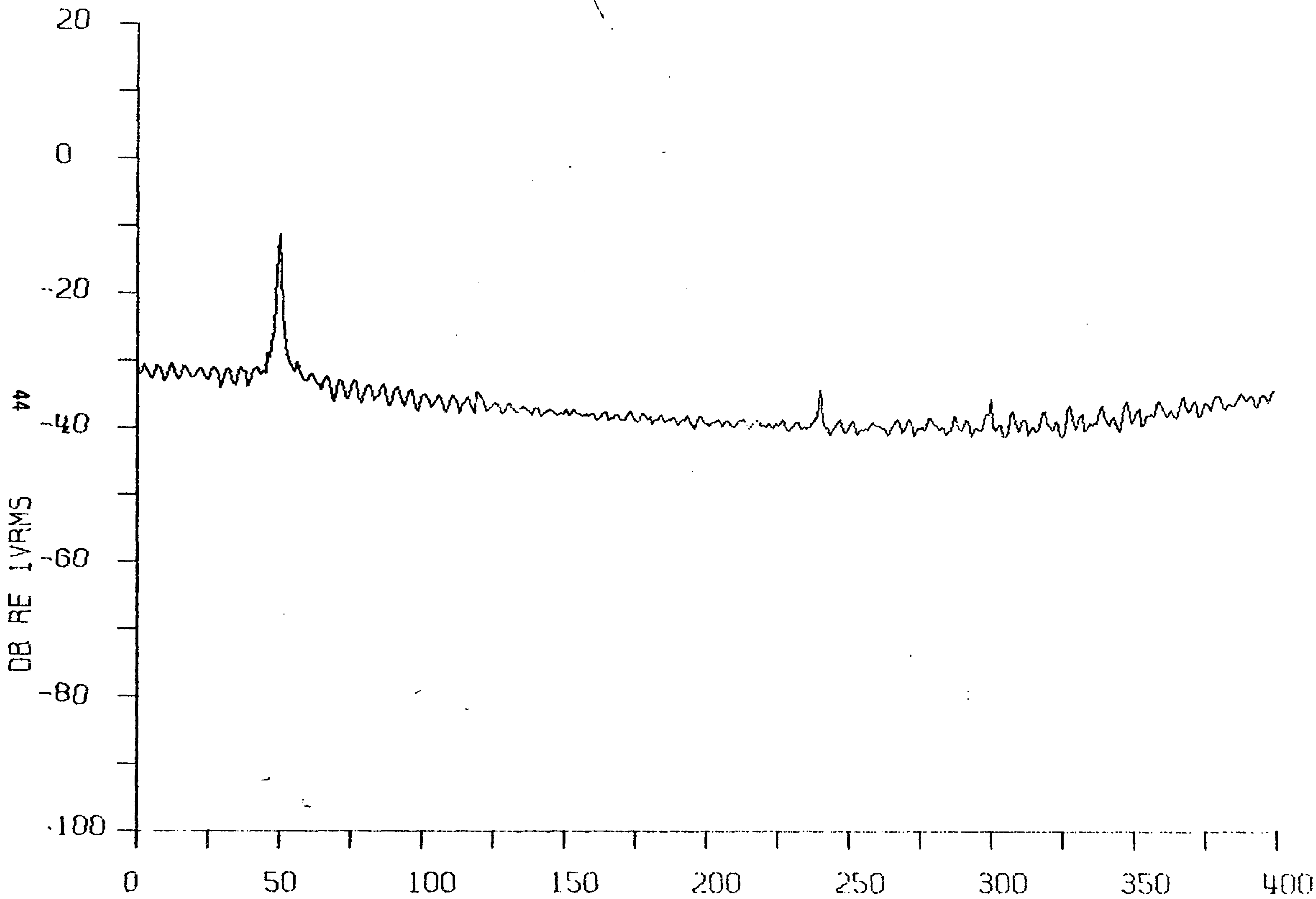


FIGURE 37. PAR SYSTEM 2 CHANNEL 13 LAB 50HZ .004V GS = 7



3. Frequency Response

a. Data Recorded

The frequency response for each gain state was determined by recording white noise, bandlimited at 300 Hz and adjusted to provide a record level of 0 dB at each gain state on all channels simultaneously.

b. System 1

Since this section of data was contaminated due to the pre-emphasis compensation circuit problem discussed previously, no direct determination of frequency response can be made for all gain states.

Using the linear dynamic range data, a plot of the frequency response at gain state 0 was constructed for channel 7 (Figure 38). This channel shows a flat response across the frequency range from 3 Hz to 300 Hz.

This response determined for system 1 from linear dynamic range data corresponds closely to the response of system 2 determined from the uncontaminated laboratory data at gain state 0. Since there was no temperature dependence noted in the linear dynamic range or gain linearity data, and since system 1 and system 2 exhibit similar characteristics for linear dynamic range, gain linearity, and self noise (subsection E-4), it can be expected that the frequency response characteristics of system 1 correspond to the frequency response characteristics of system 2 as discussed below.

c. System 2

Data recorded in the environmental chamber was contaminated by the pre-emphasis circuit problem. A frequency response curve (Figure 39) was drawn from the linear dynamic range data and shows a flat response across the frequency range from 25 Hz to 300 Hz on channel 5.

Under laboratory conditions the white noise data recorded for the purpose of determining frequency response was uncontaminated. Figures 40 through 46 show the white noise spectrum on channel 7 at each gain state. These plots show that the frequency response is not a function of gain state. At all gain states system 2 showed a flat response across the range of frequencies from 25 to 300 Hz. This response resembles that obtained from the linear dynamic range data for system 2 under

FIGURE 38. PAR SYSTEM 1 ENVIRONMENT FREQUENCY RESPONSE CHANNEL 7 (GS=0)

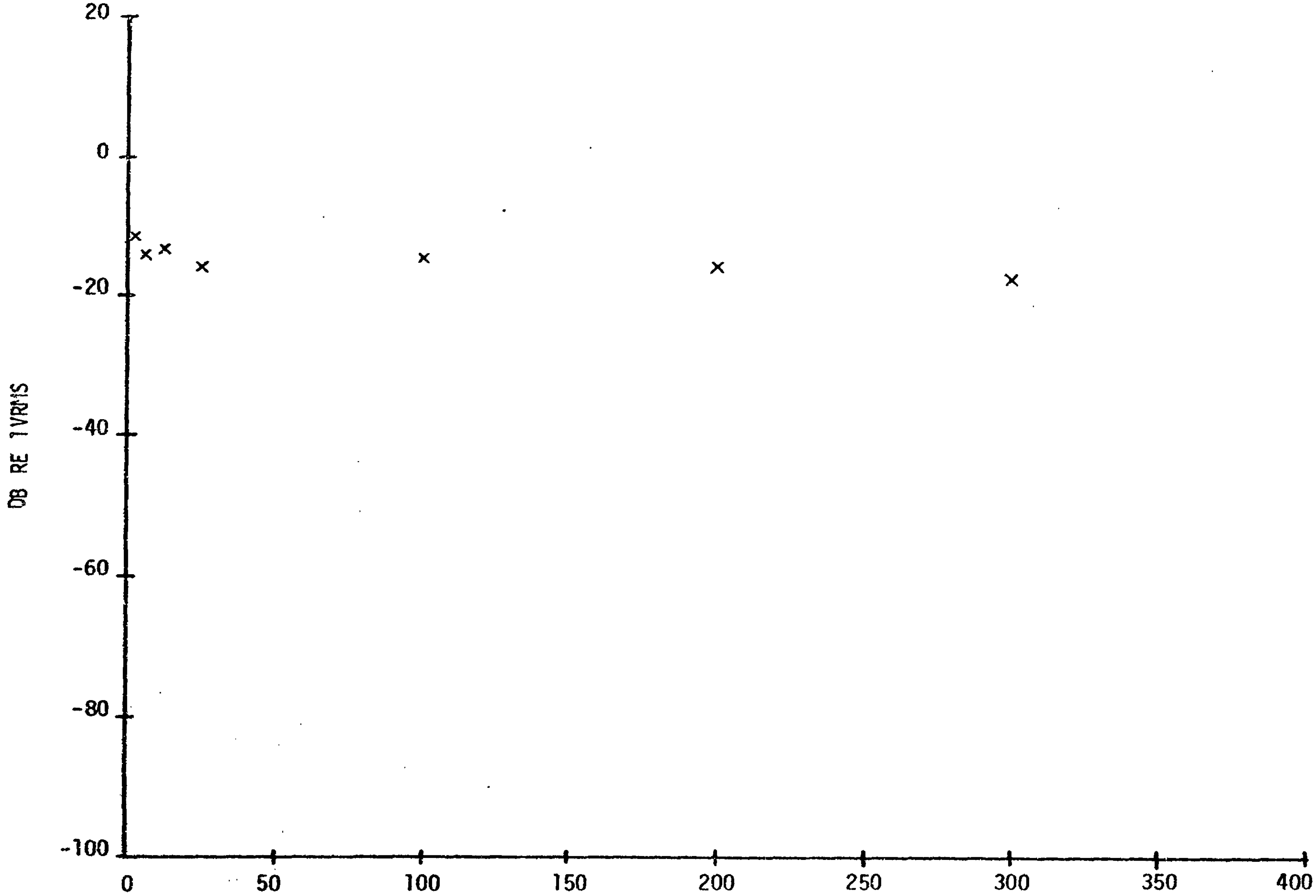


FIGURE 39. PAR SYSTEM 2 ENVIRONMENT FREQUENCY RESPONSE CHANNEL 13 (GS=0)

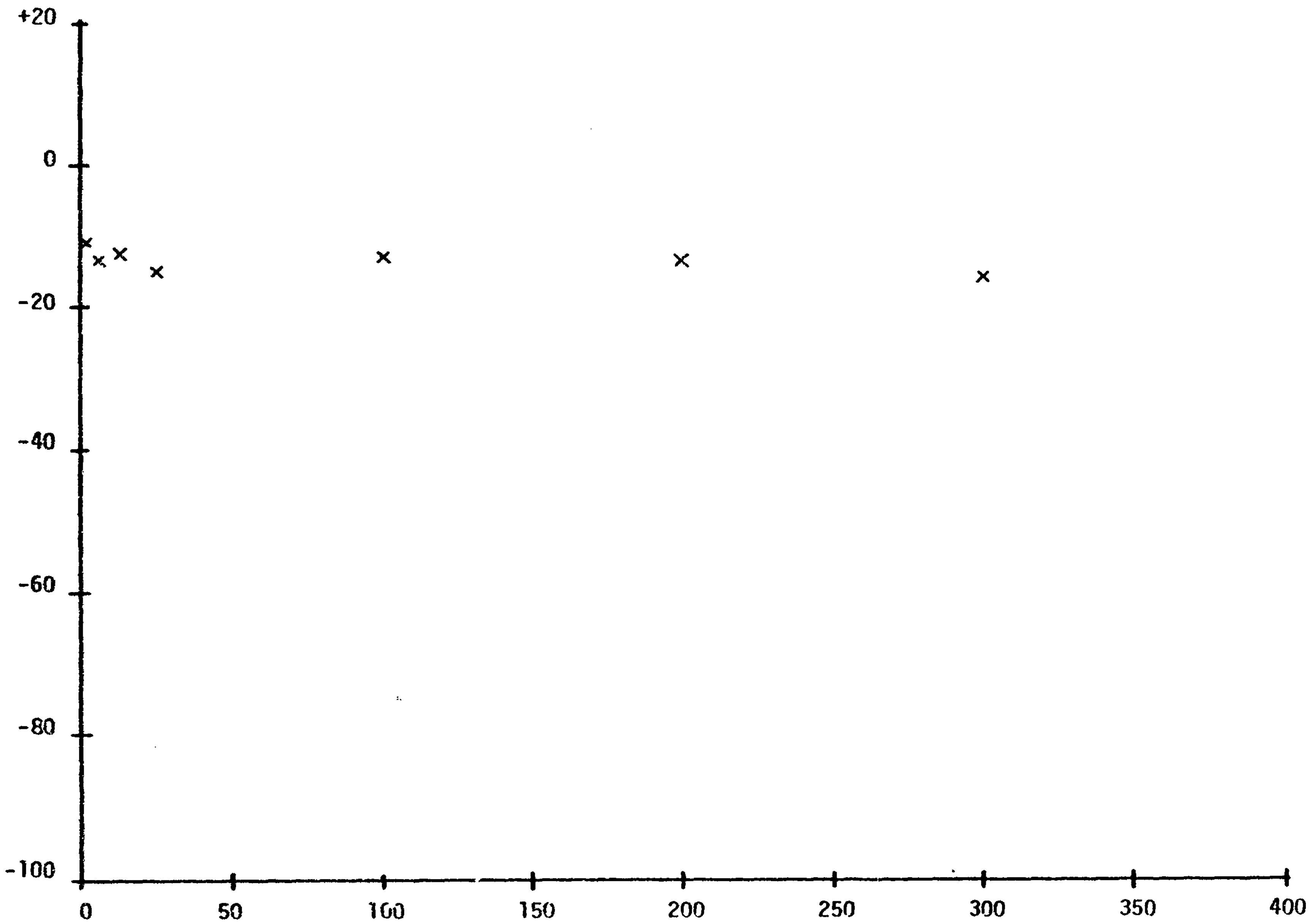


FIGURE 40. PAR SYSTEM 2 LAB WHITE NS CHANNEL 13 GS = 0

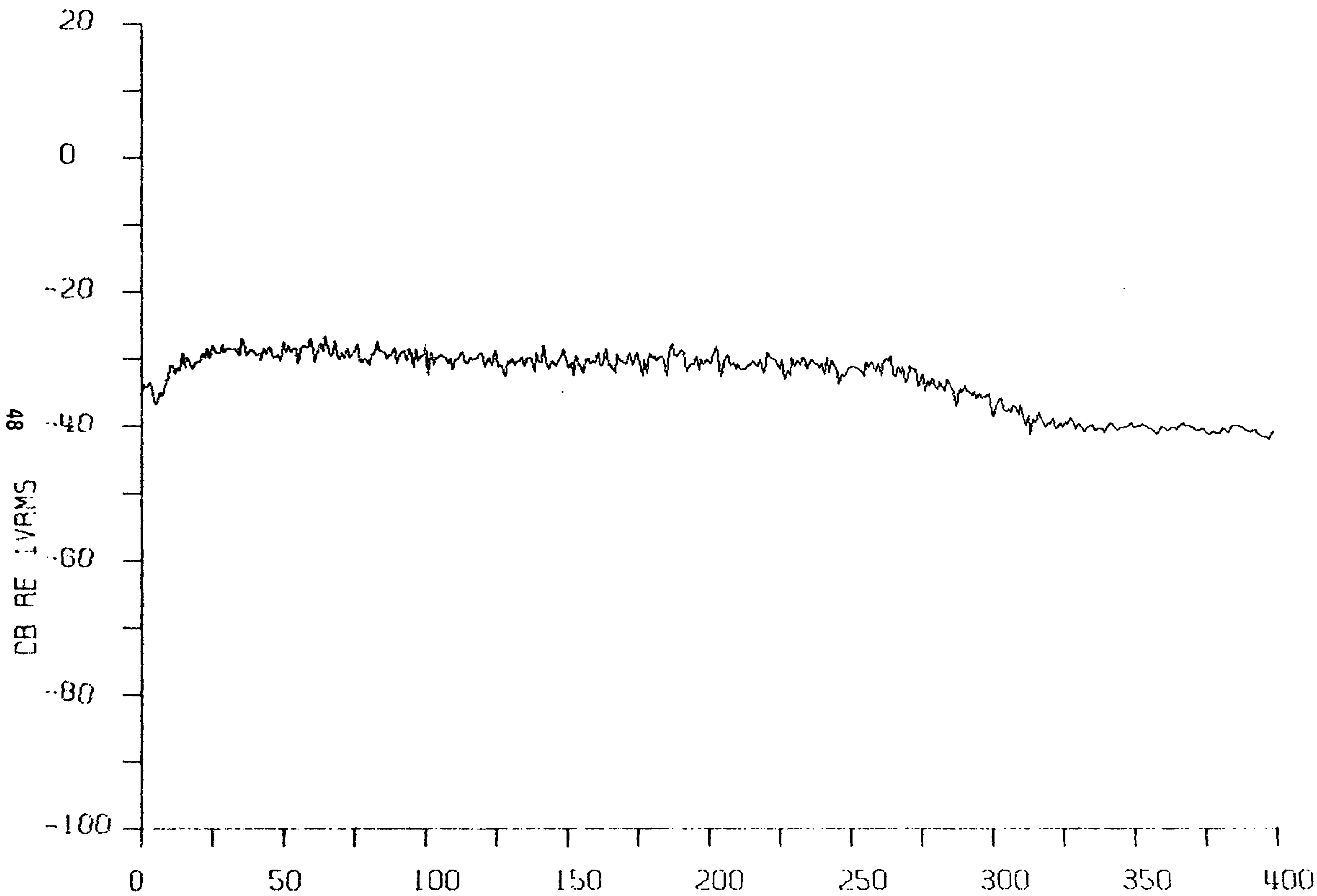


FIGURE 41. PAR SYSTEM 2 LAB CHANNEL 13 WHITE NS GS = 1

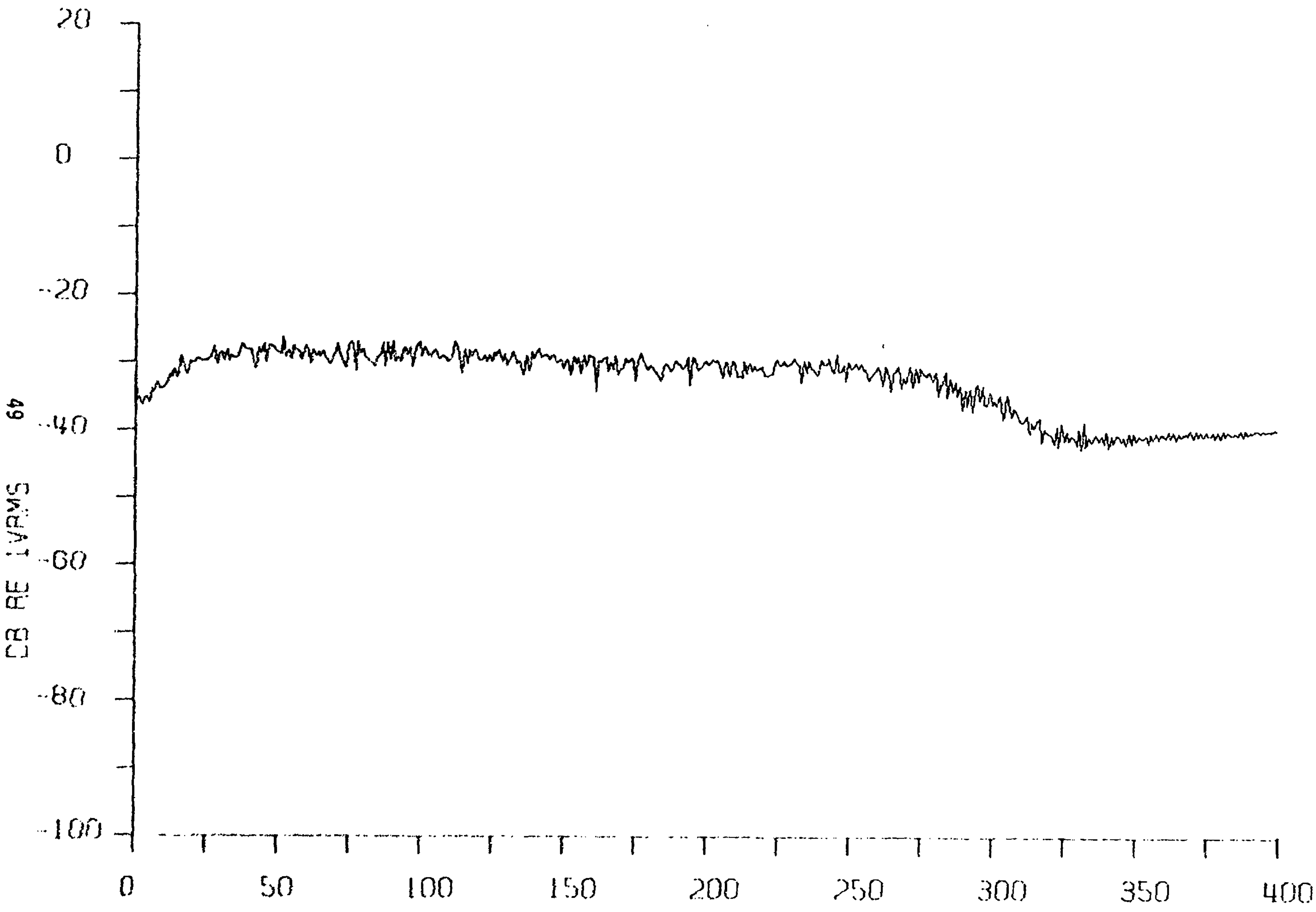


FIGURE 42. PAR SYSTEM 2 CHANNEL 13 LAB WHITE NS GS = 2

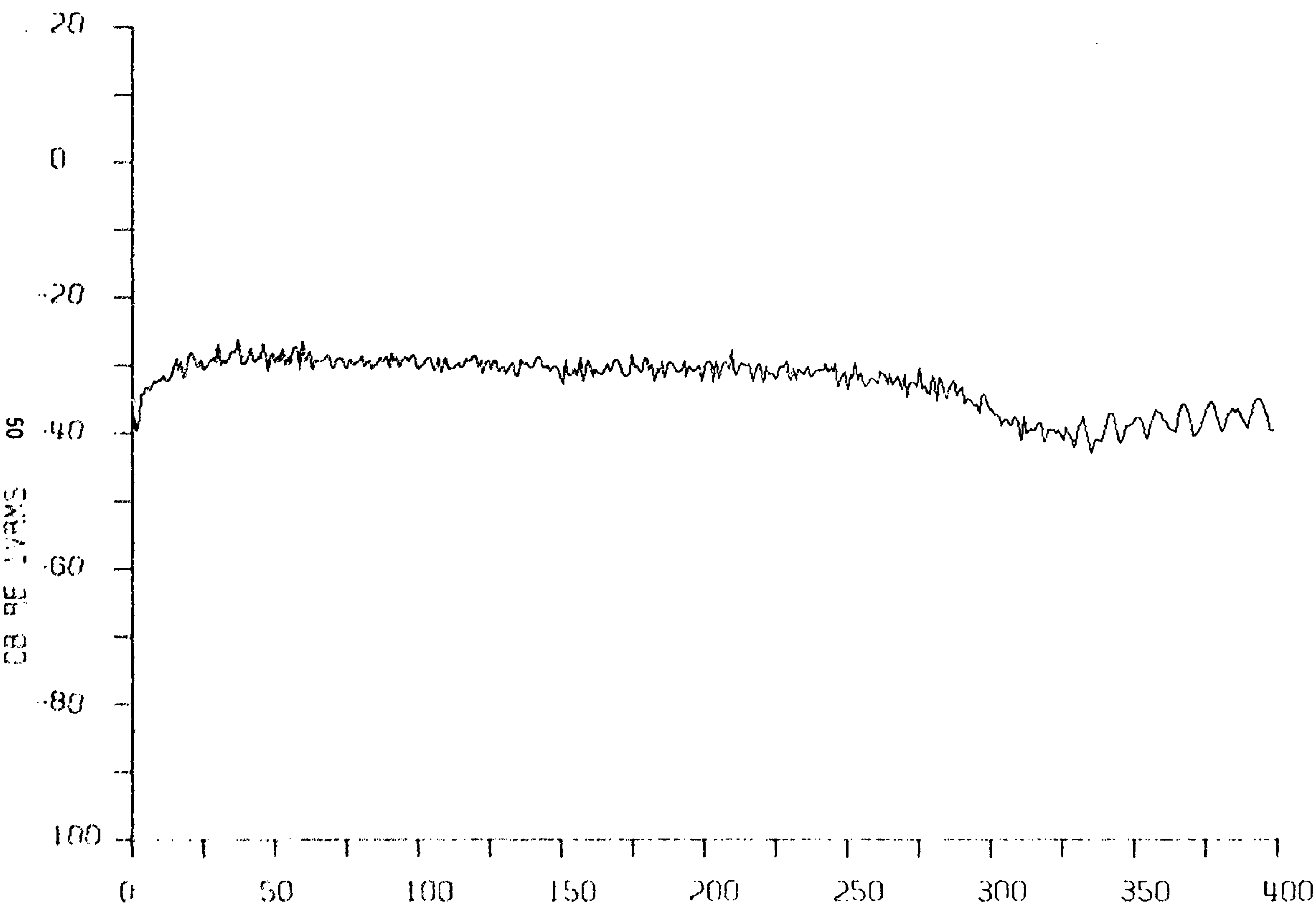


FIGURE 43. PAR SYSTEM 2 LAB CHANNEL 13 WHITE NS GS = 3

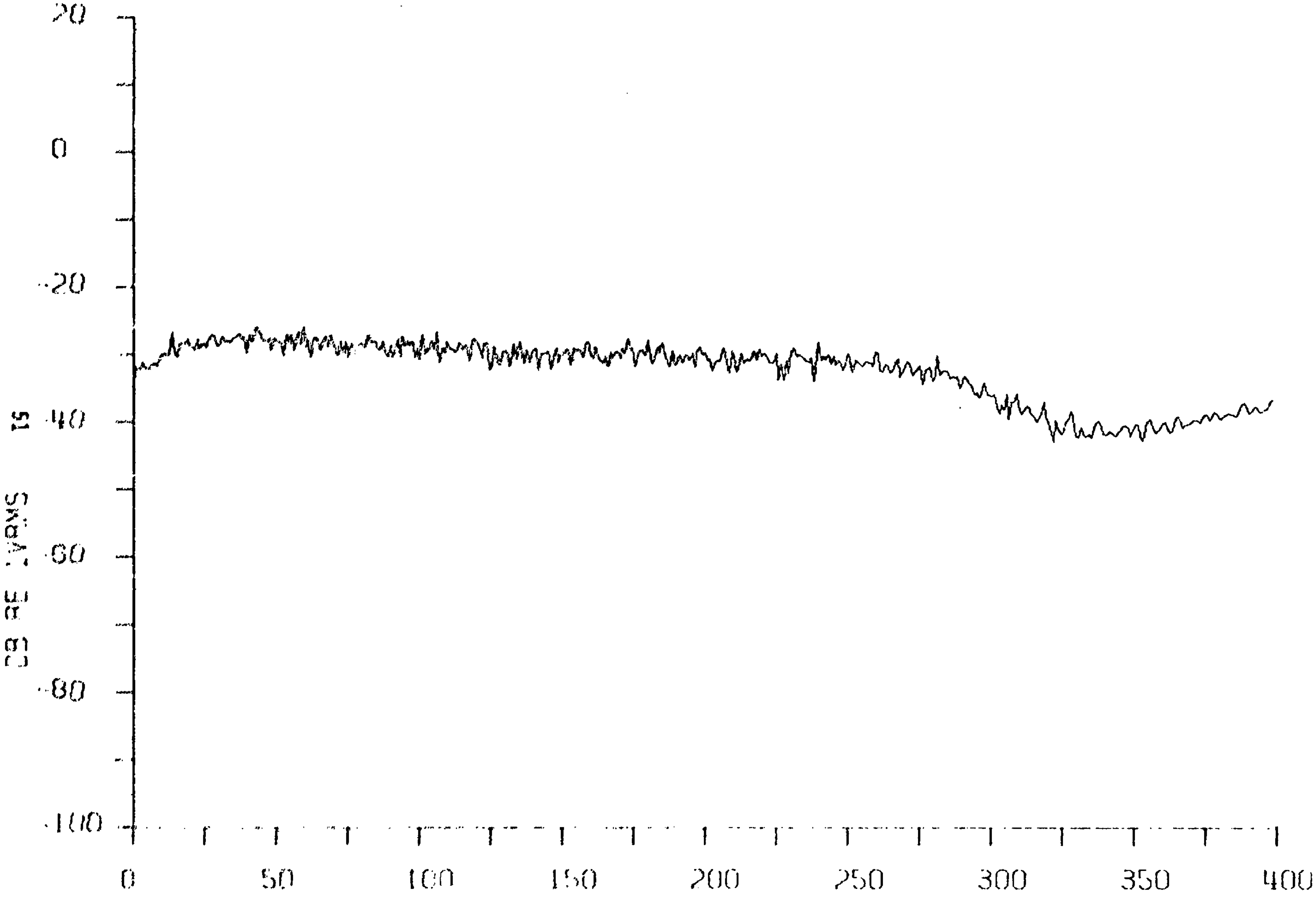


FIGURE 44. PAR SYSTEM 2 LAB CHANNEL 13 WHITE NS GS = 4

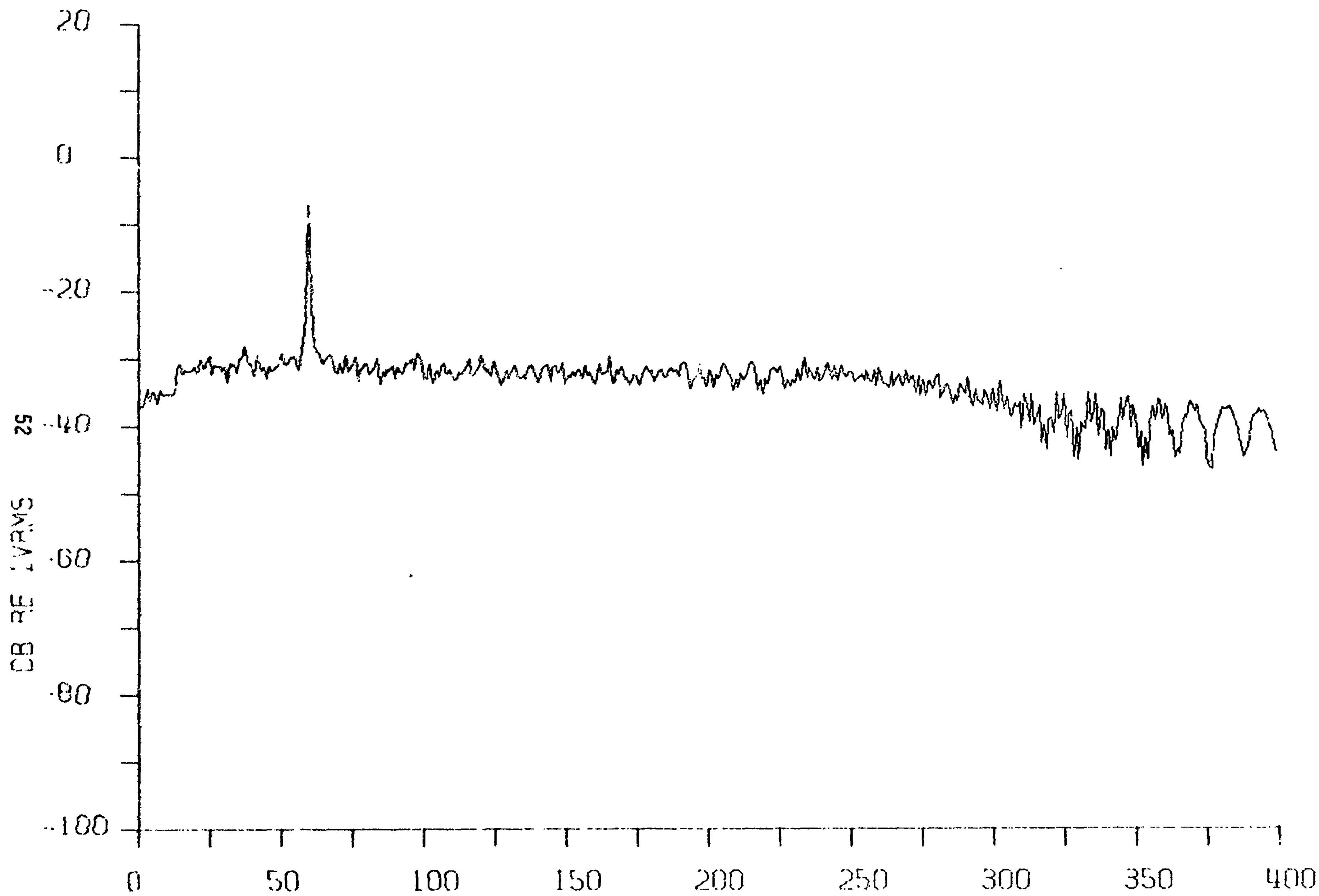


FIGURE 45. PAR SYSTEM 2 LAB CHANNEL 13 WHITE NS GS = 5

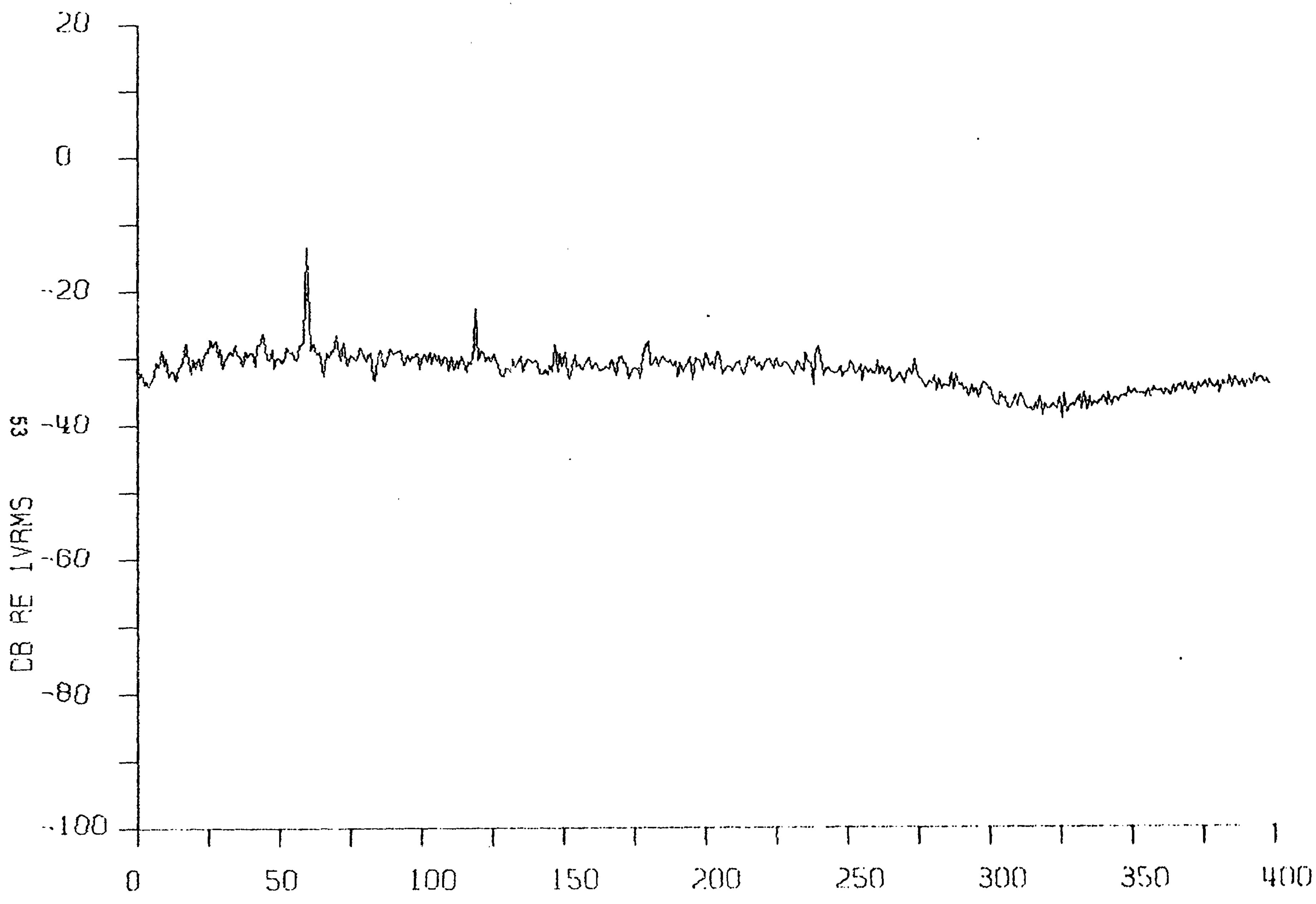
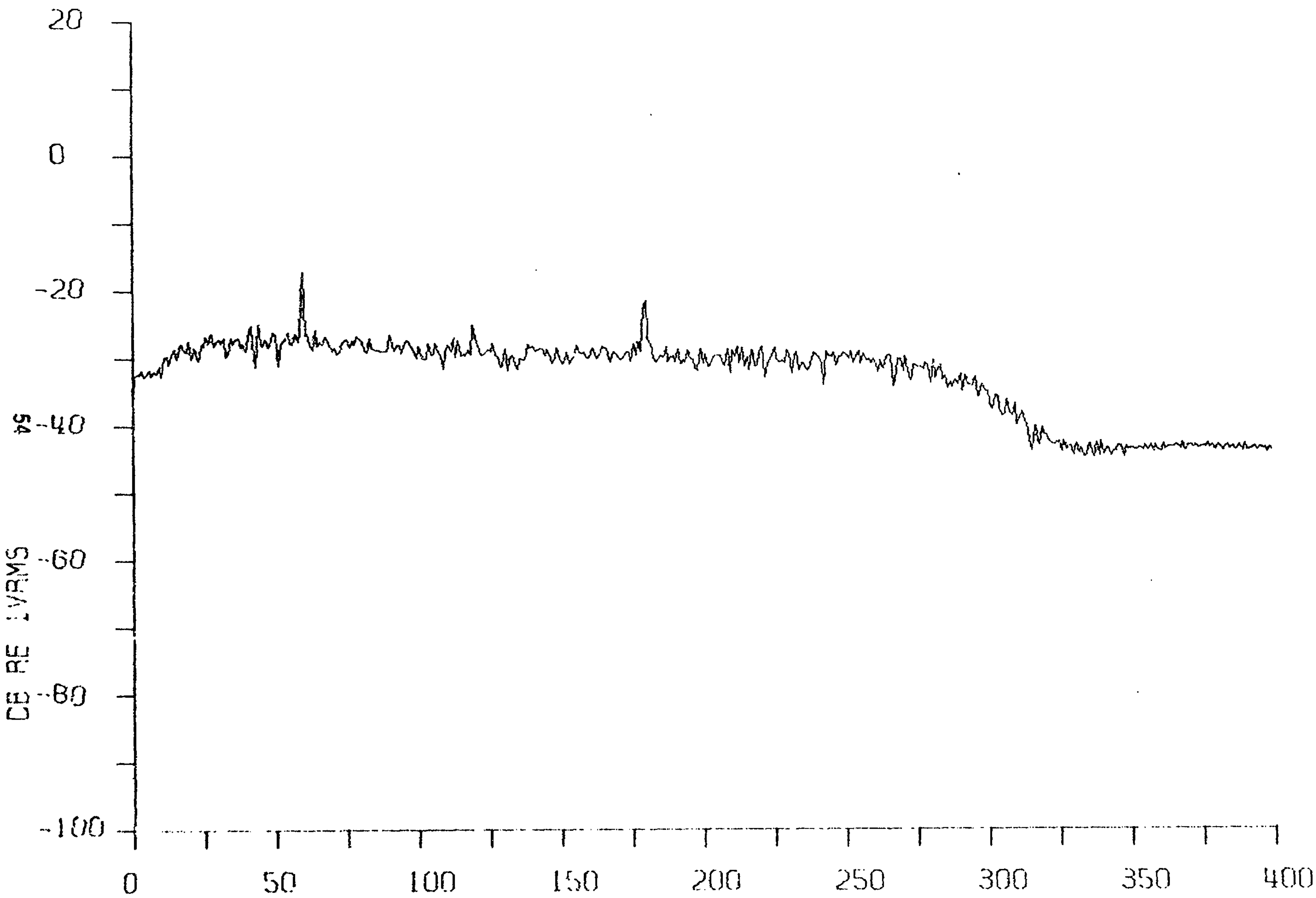


FIGURE 46. PAR SYSTEM 2 LAB CHANNEL 12 WHITE NS GS = 7



environmental conditions. Since the linear dynamic range data and the gain linearity data showed no temperature dependence it can be inferred that the frequency response of system 2 under environmental conditions is not a function of gain state and shows a flat response across the frequency range 25 Hz to 300 Hz.

d. Interpretation of Frequency Response Data

Since the input signal was compensated for the effects of pre-emphasis in the PAR signal conditioning circuits, the expected frequency response of the system was a "flat" response across the spectrum. This coincides with the processed results.

The test as performed here can be used to show that frequency response is independent of gain state. The true frequency response of the system can be inferred from the response of the PAR system pre-emphasis shown in Figure 47. It is obvious from this figure that pre-emphasis should roll the input signal up by a factor close to the theoretical 6 dB per octave at frequencies above 50 Hz.

4. Self Noise

a. Data Recorded

Sequences of data were recorded with inputs to the PAR electronics packages terminated in the characteristic impedance of the pre-amp. Data amplifier gains were set to 0, 18, 30, and 42 dB.

b. System 1

Since noise data was not sent through the pre-emphasis compensation network,noise data is uncontaminated and can be used for a determination of the noise floor of system 1.

Figures 48 through 51 show the spectrum of the noise data on channel 7 in gain state 0, 3, 5, and 7 to be -50 dBV/Hz over the frequency region greater than 100 Hz and to increase slightly in the region below 100 Hz. Similar results were obtained from the other channels in system 1 and there was less than 5 dB variation in noise level among the 13 channels.

c. System 2

Figures 52 through 55 show the noise floor of channel 13 under laboratory conditions at gain states 0, 3, 5, and 7. Gain states 3, 5, and 7 have picked up and amplified the 60 Hz line current used to power the system. For comparison purposes Figure 56 shows the self noise at gain state 0 on channel 13 under environmental conditions. The 195 Hz spike in the environmental data is a latent signature on the tape. A comparison of the environmental and laboratory data shows no difference in noise level; the system noise floor is completely independent of temperature.

FIGURE 47. PAR SYSTEM PRE-EMPHASIS

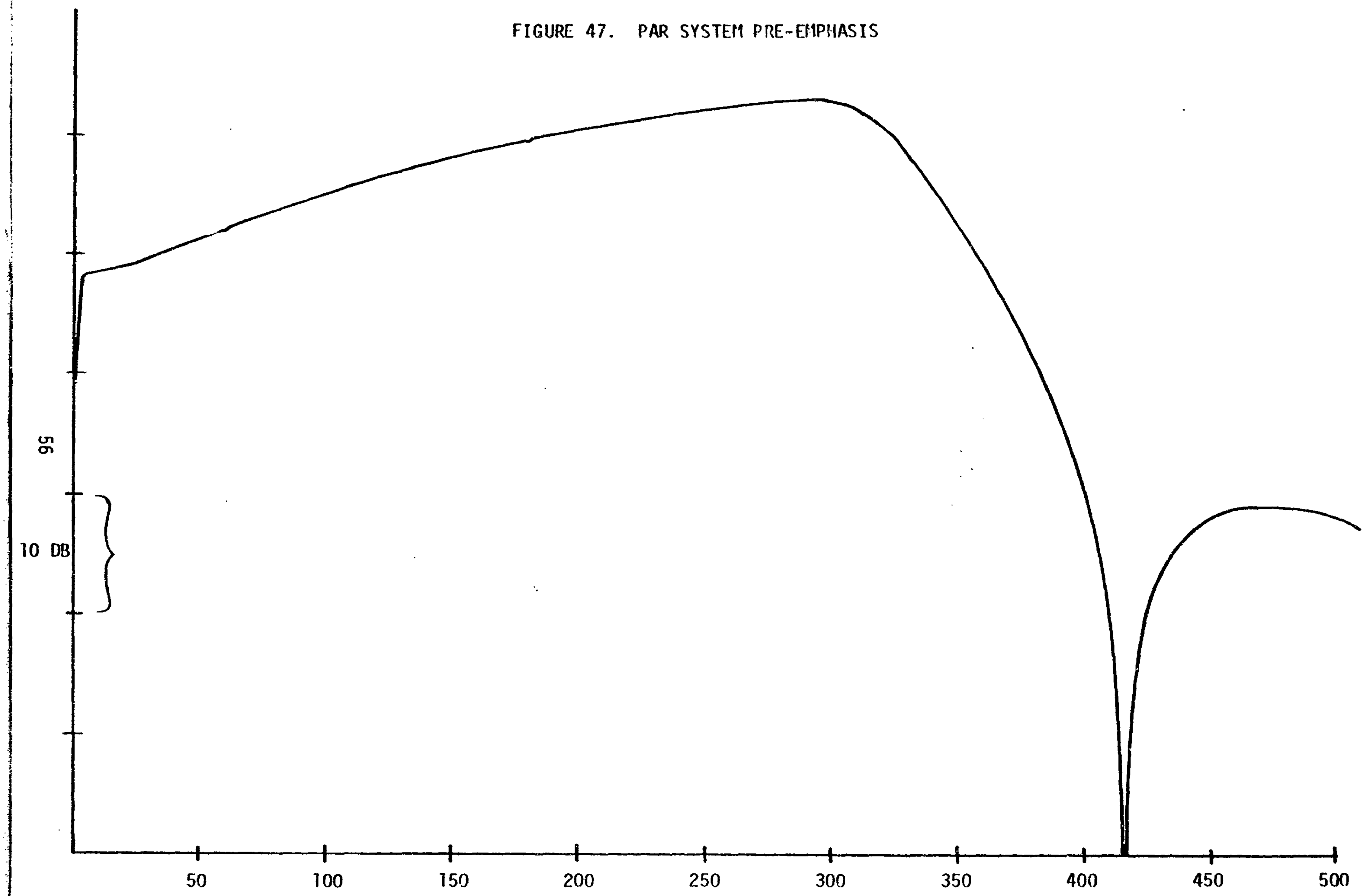


FIGURE 48. PAR SYSTEM 1 ENVIRONMENTAL CHANNEL 7 SYSTEM NOISE GS = 7

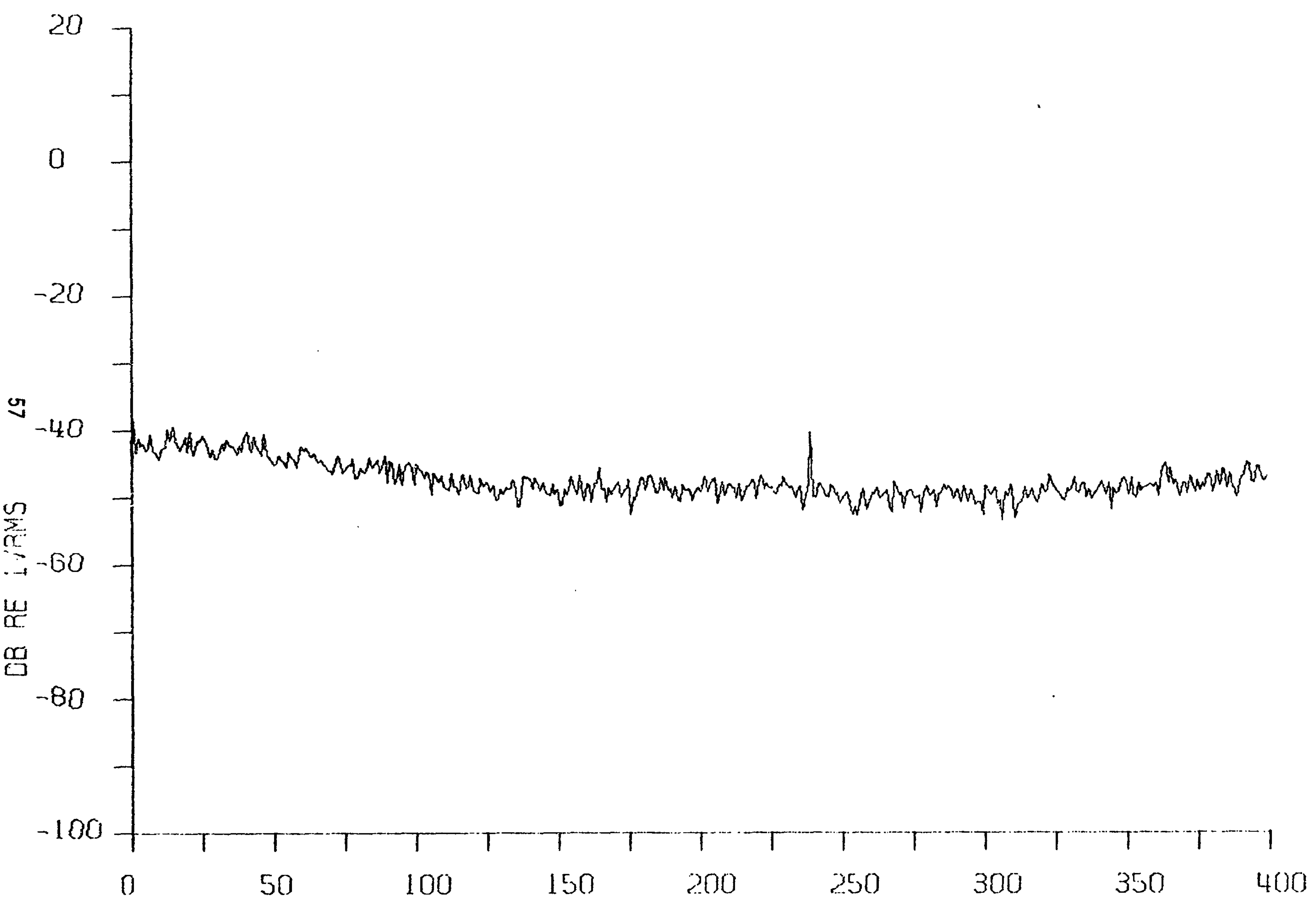


FIGURE 49. PAR SYSTEM 1 ENVIRONMENT CHANNEL 7 SYSTEM NOISE GS = 5

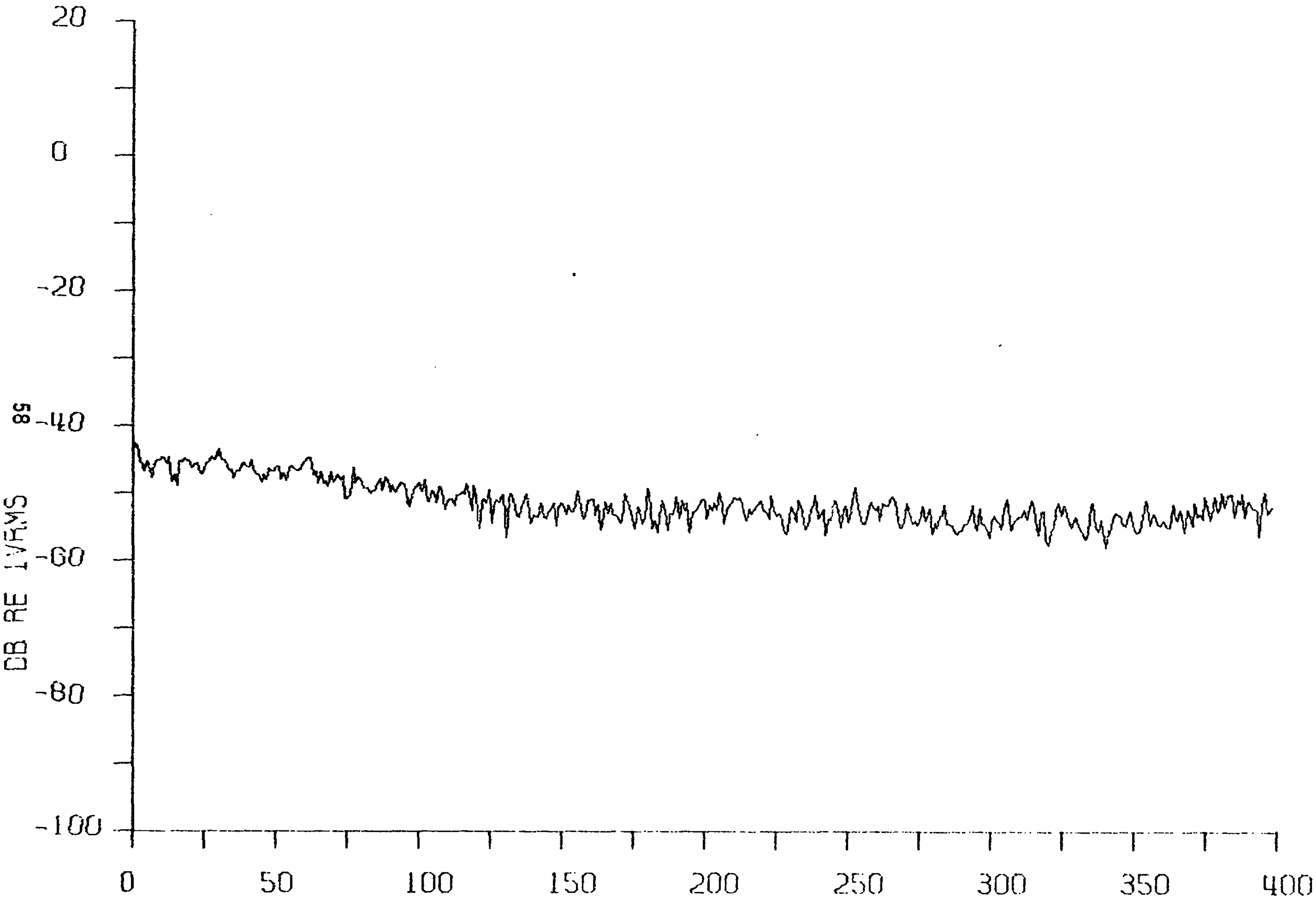


FIGURE 50. PAR SYSTEM 1 ENVIRONMENT CHANNEL 7 SYSTEM NOISE GS = 3

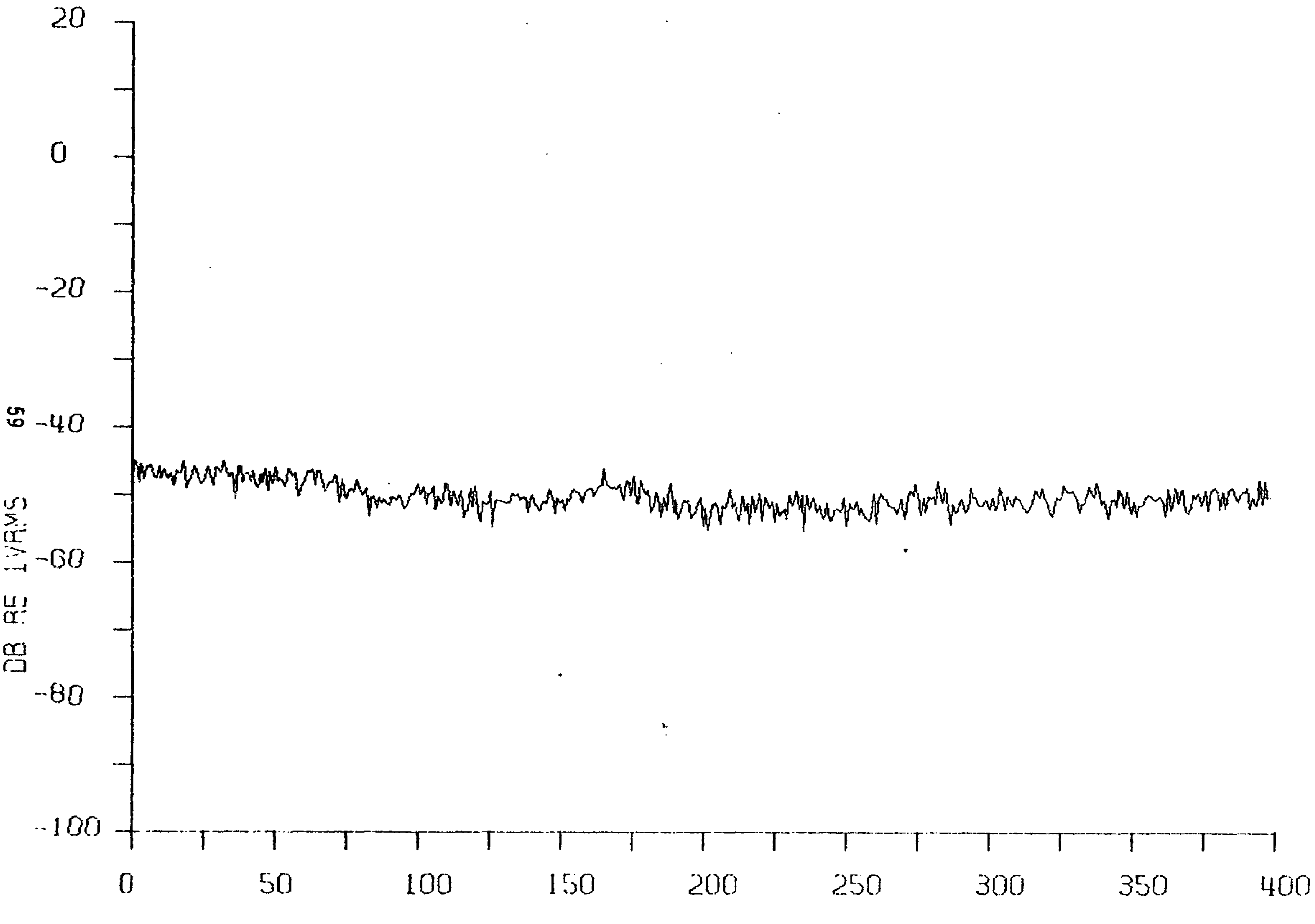


FIGURE 51. PAR SYSTEM 1 ENVIRONMENT CHANNEL 7 GS = 0

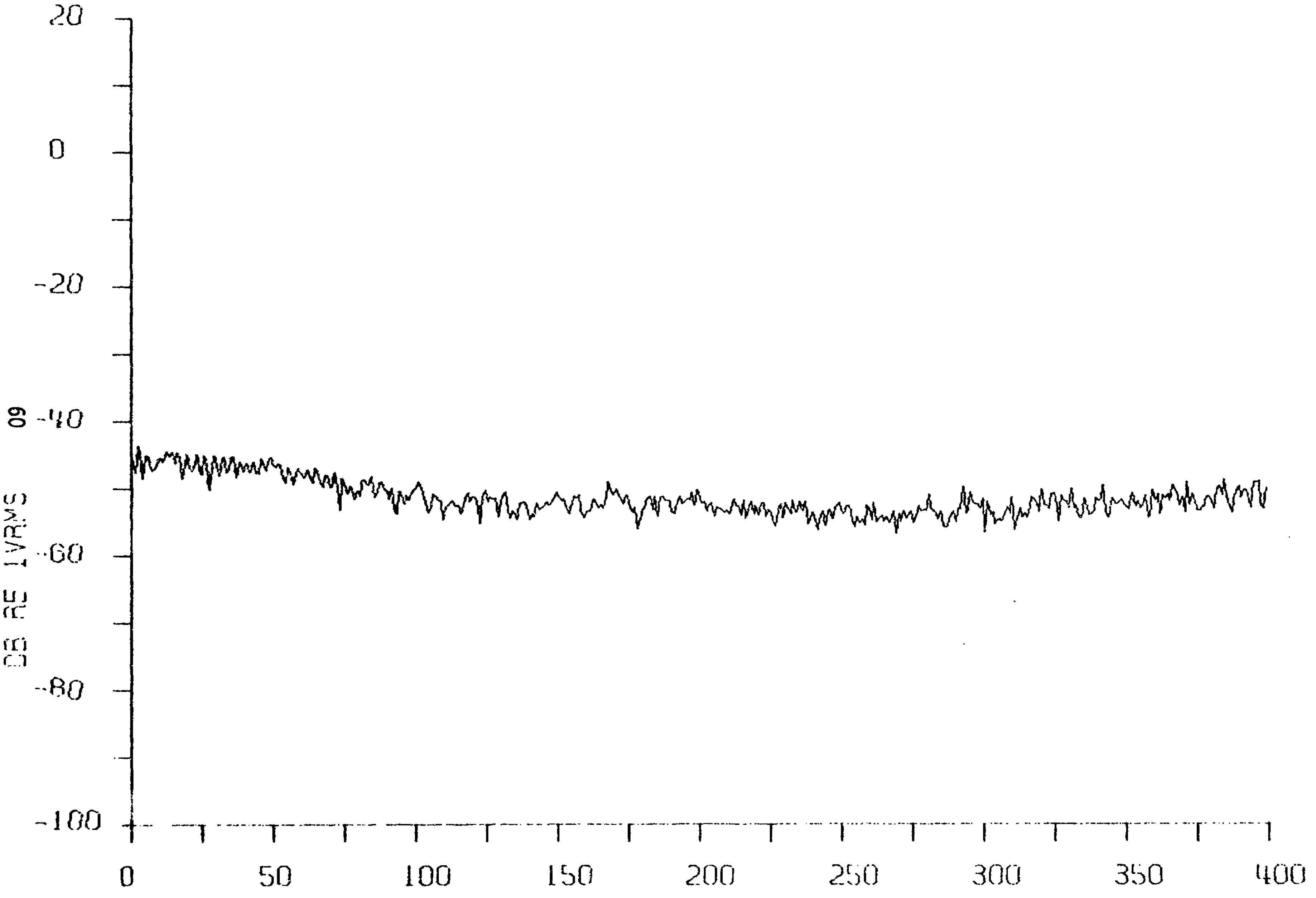


FIGURE 52. PAR SYSTEM 2 LAB CHANNEL 13 SELF NOISE GS = 0

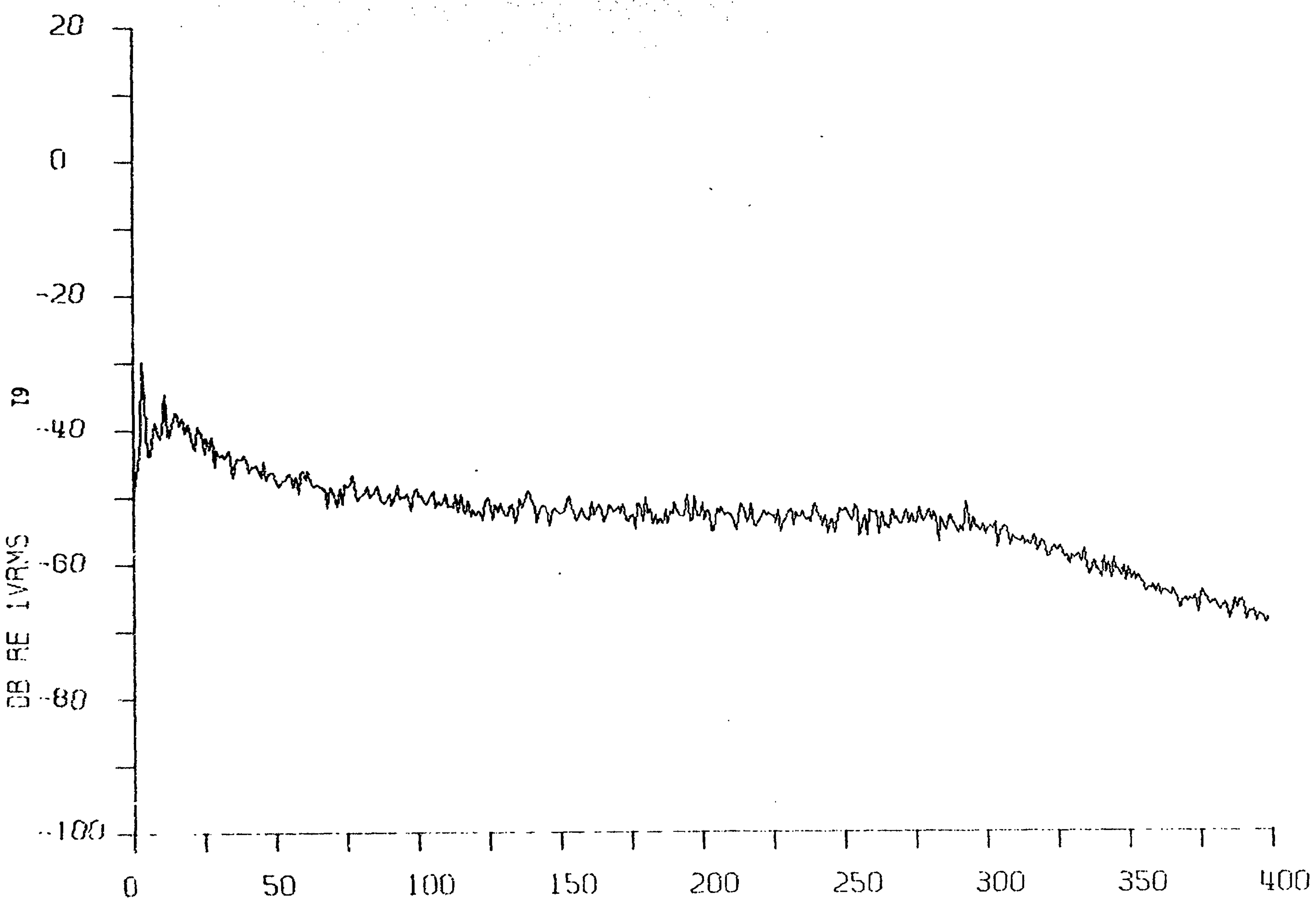


FIGURE 53. PAR SYSTEM 2 LAB CHANNEL 13 SELF NOISE GS = 3

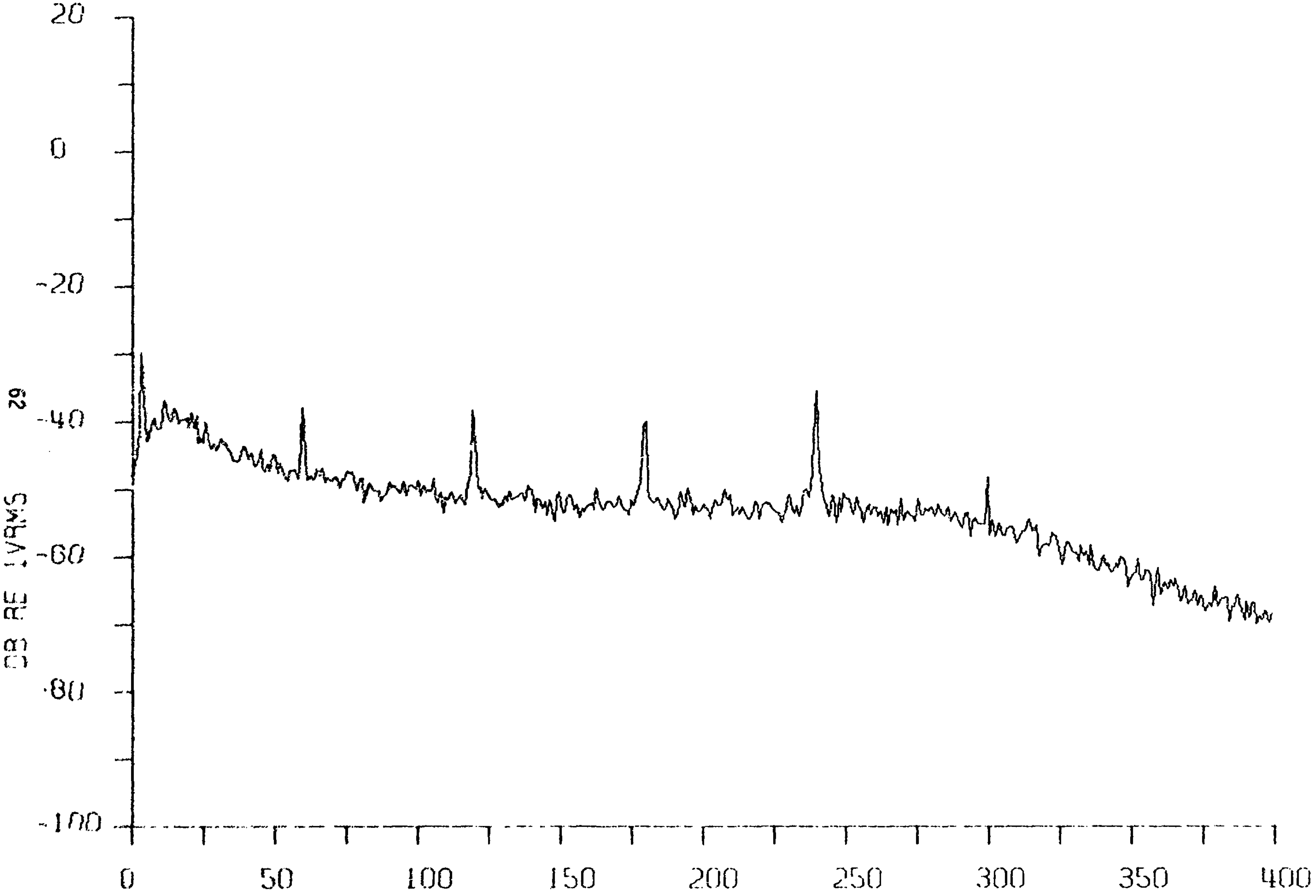


FIGURE 54. PAR SYSTEM 2 LAB CHANNEL 13 SELF NOISE GS = 5

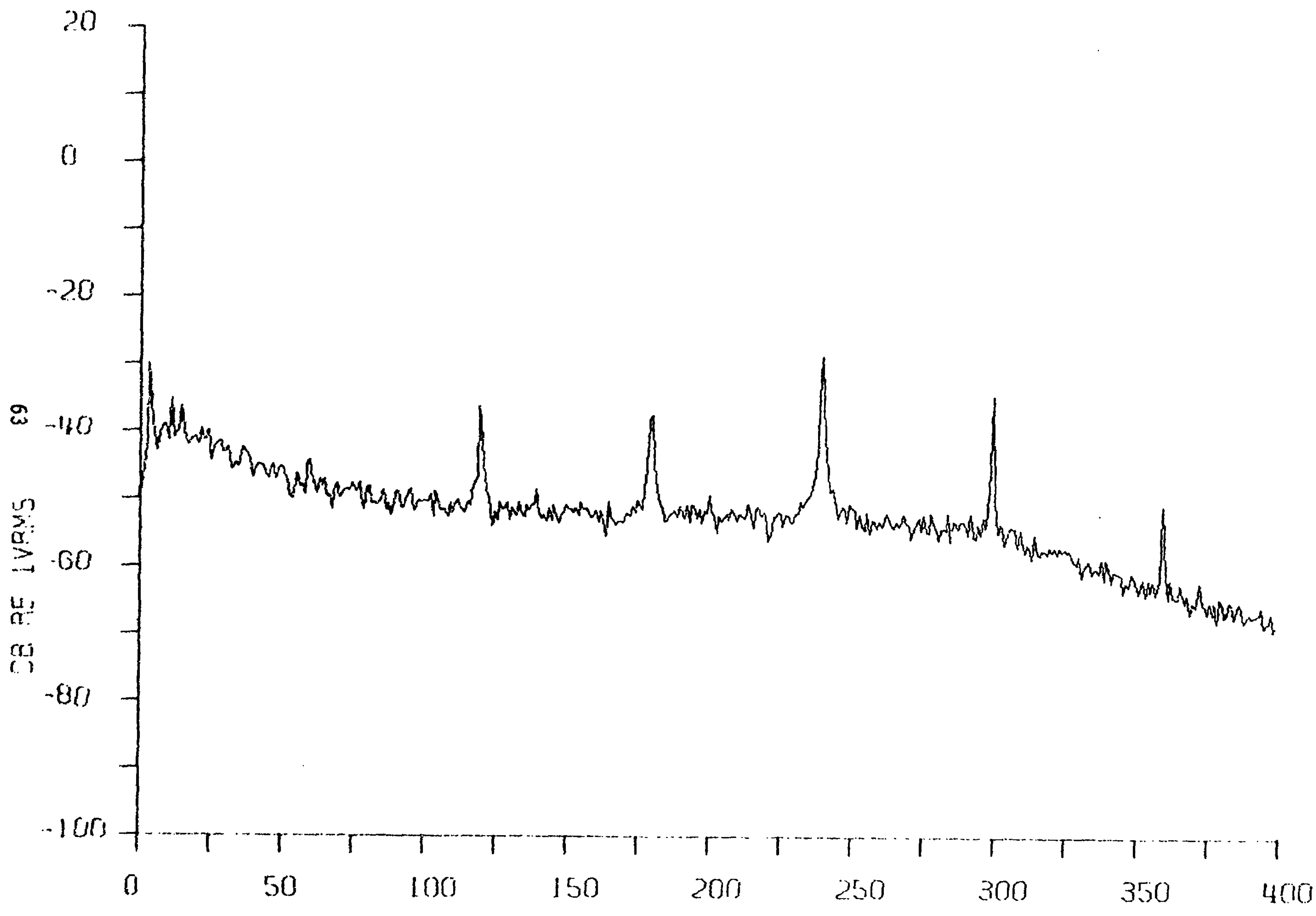


FIGURE 55. PAR SYSTEM 2 LAB CHANNEL 13 SELF NOISE GS = 7

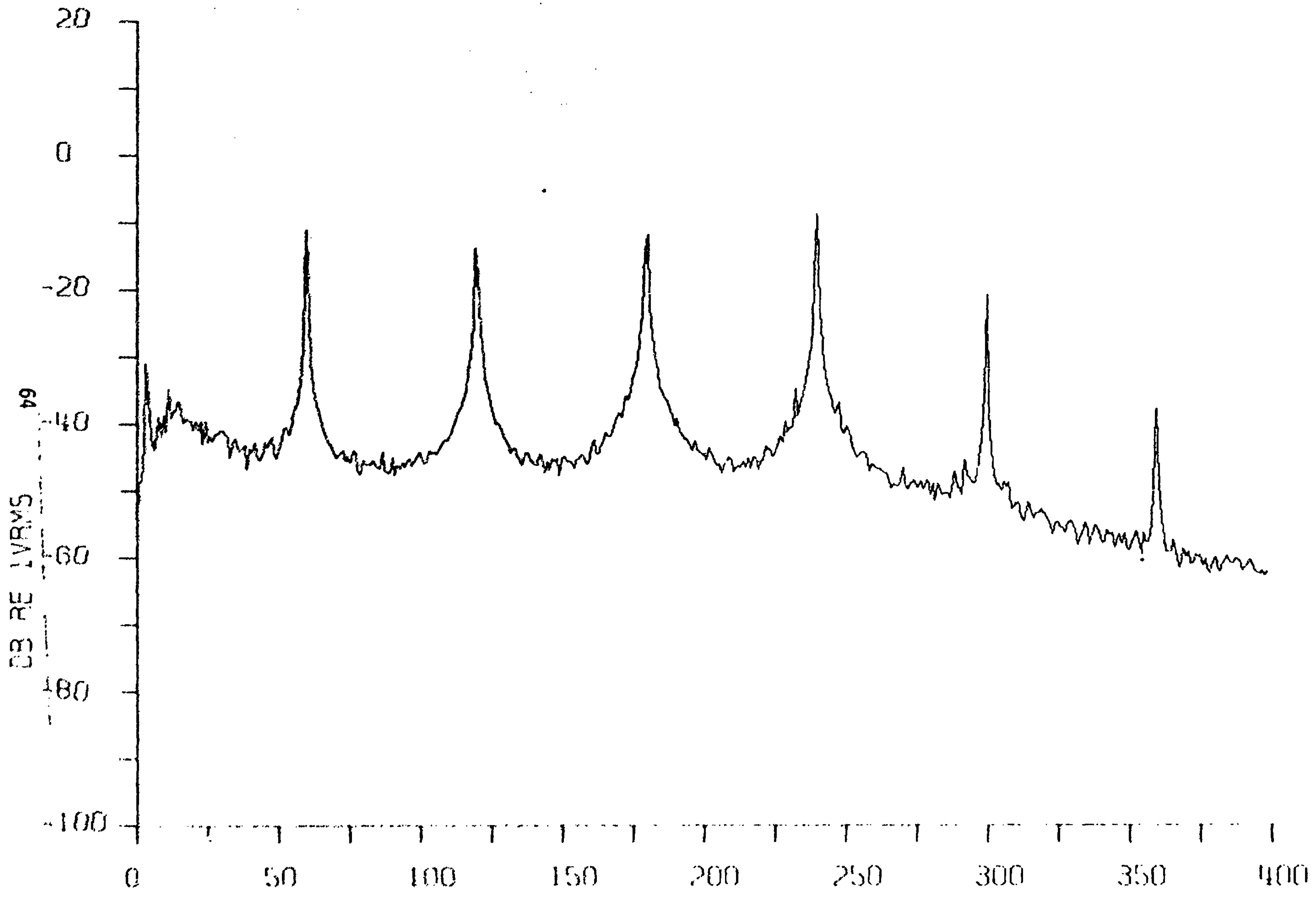
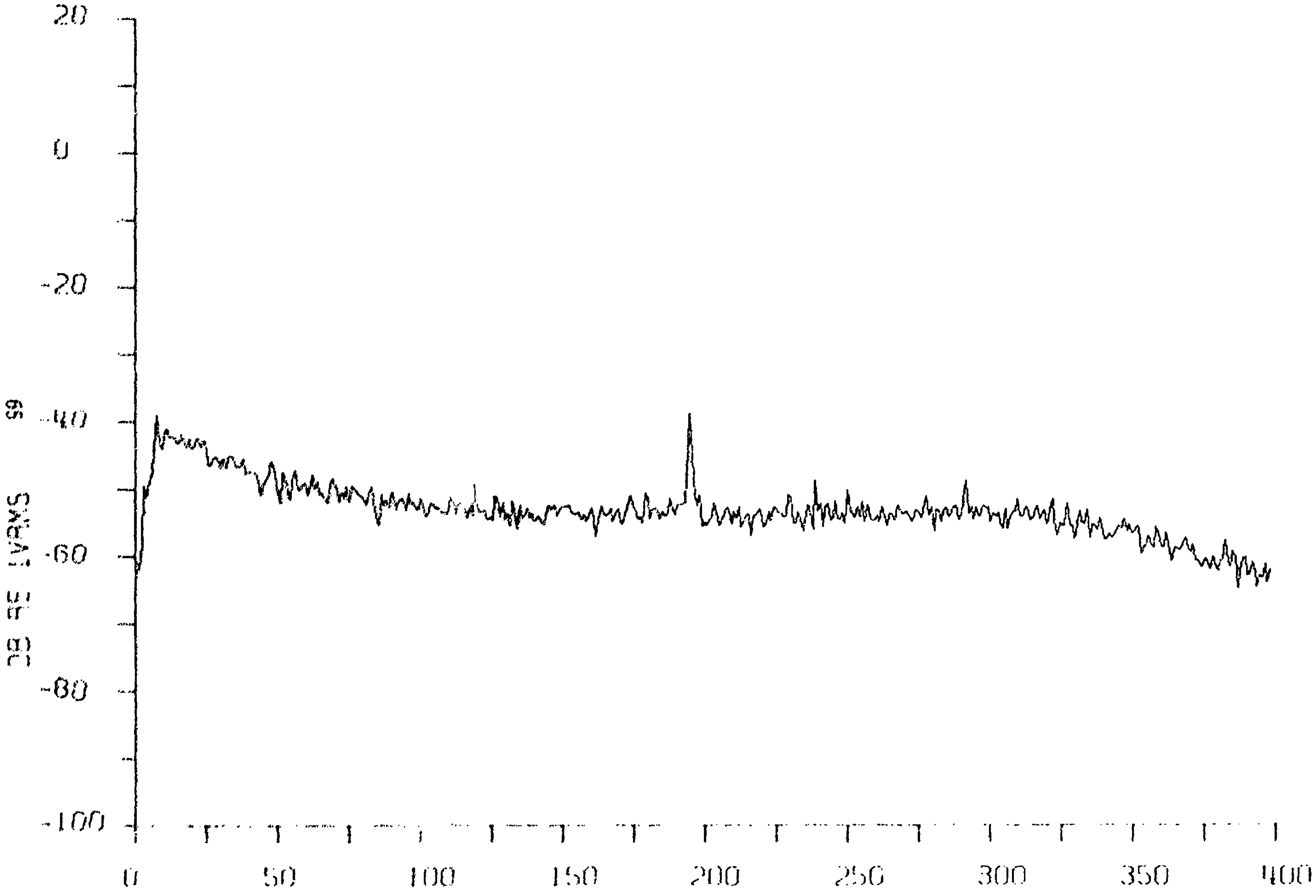


FIGURE 56. PAR SYSTEM 2 ENVIRONMENT CHANNEL 13 SYSTEM NOISE GS = 0



Similar results were obtained on all other channels. As with system 1, the noise floor variation from channel to channel is less than 5 dB, and is independent of temperature.

5. Frequency Modulation Noise

a. Data Recorded

Data recorded for the linear dynamic range, gain linearity, and interchannel crosstalk was used to determine the magnitude and frequency of any sidebands present.

b. System 1

Even though the linear dynamic range data was contaminated under both laboratory and environmental conditions by the pre-emphasis compensation circuit, some evidence of sidelobes can be seen in the spectra of the 50 Hz tone used for the gain linearity check (Figures 19 through 26). These sidelobes appear at all gain states and are on the order of 25 dB below the primary peak equally spaced about 5 Hz away from the primary lobe on either side. However, since these sidelobes do not appear on similar data that is recorded on system 2 under laboratory conditions (without overloaded pre-emphasis compensation circuit), it is possible that they may be associated with the above described pre-emphasis compensation circuit problem. It is also possible they are actually introduced by the digitization process as described in the next paragraph.

c. System 2

As mentioned previously there is no evidence of the presence of sidelobes in the spectra of the 50 Hz tone used for the gain linearity test. However, the 50 Hz tone recorded for the interchannel crosstalk test does show these same sidelobes. Sidelobes are also present in some sections of the linear dynamic range data, but not in all sections (See Figures 4 through 7).

A possible explanation for the appearance of these particular sidelobes follows from the fact that all data was sampled by an A/D converter driven by a clock not synchronized to the reproduce tape recorder. Since the data was reproduced without tape speed compensation, the sidelobes could be the result of a constant rate clock being used to sample a tone varying in frequency due to recorder wow and flutter. If this were the case, a sample clock synchronized to the playback speed or tape speed compensation should eliminate the problem.

6. Harmonic Distortion

a. Data Recorded

Linear dynamic range data was used to determine the magnitude of any harmonics of the primary tone present in the spectrum.

b. System 1

Since the pre-emphasis compensation circuit contaminated the harmonic content of system 1 data, no direct conclusions can be drawn about the presence of harmonics in the primary tone. However, since the characteristics of system 1 and system 2 have been similar for the other tests performed, there should also be a similarity between systems in terms of harmonic distortion. Therefore, the second, third, and fourth harmonics would be expected to be at least 35 dB below the main lobe as is discussed in paragraph c for system 2.

c. System 2

Data recorded in the laboratory was free of any spurious harmonics from the pre-emphasis compensation circuit. The spectra of the 25 Hz and 100 Hz tones shown in Figures 4 and 5 show no evidence of second or third harmonics in their spectra. The 25 Hz peak is approximately 35 dB above the noise level at 50 Hz and 40 dB above the noise at 75 Hz. Similarly the 100 Hz peak is over 40 dB above the noise levels at 200 Hz and 300 Hz. Based on the fact that other characteristics of the PAR system are temperature independent, it is reasonable to expect that environmental data would exhibit harmonic distortion similar to that observed in the laboratory. In this case the environmental data should have shown no evidence of second or third harmonics at 25 or 100 Hz. Similar results would also be expected on all channels, since no significant channel to channel variations have been noted in other tests.

7. Interchannel Crosstalk

a. Data Recorded

Single sine waves of 50 Hz and 300 Hz were recorded on each channel separately. The signal level was set to -6 dB with data amplifier gain set to minimum gain. Inputs to channels on which the tones are not recorded are terminated in the characteristic impedance of the hydrophone pre-amplifiers.

b. System 1

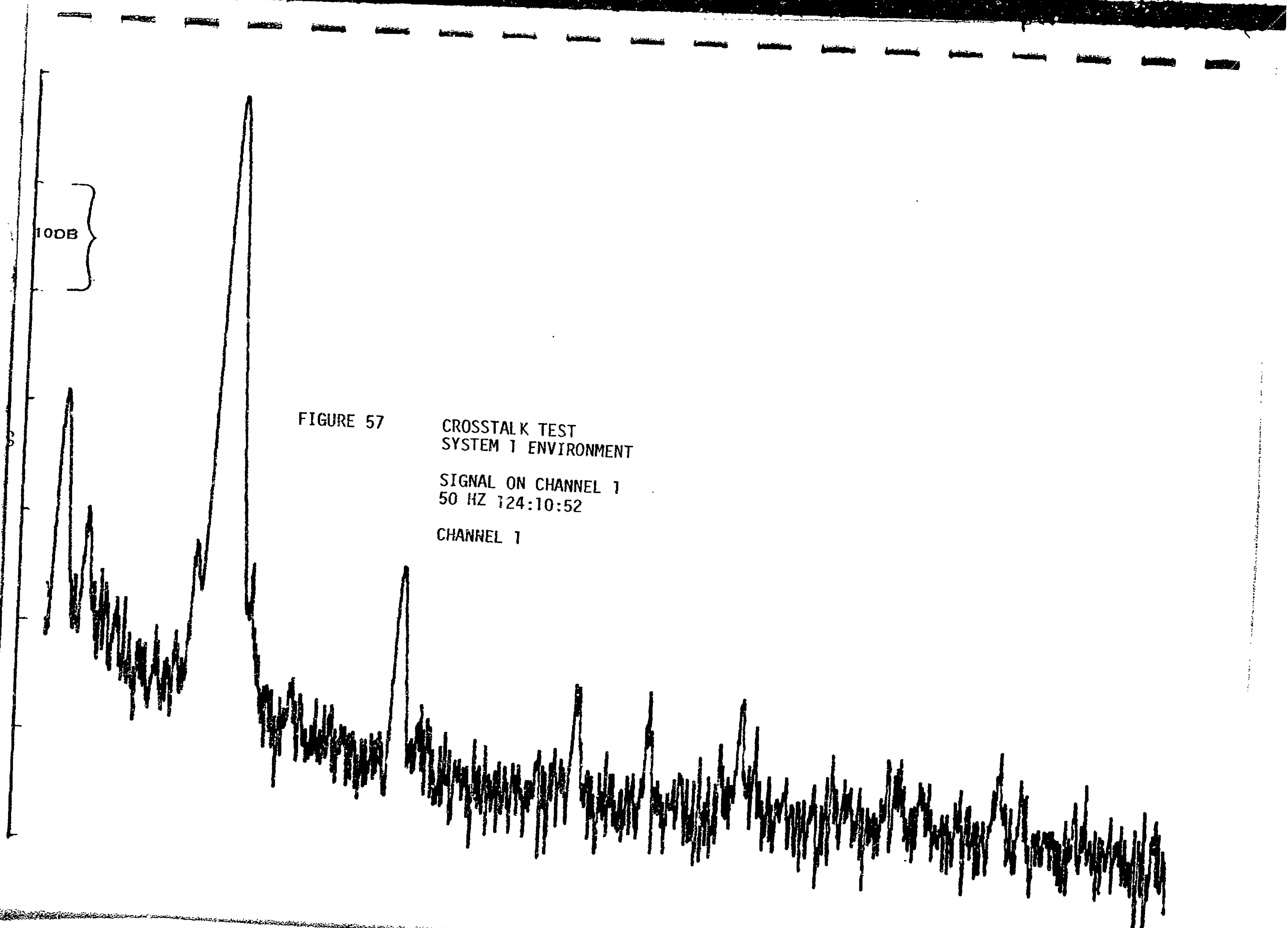
Figures 57 through 82 show the spectra of the 50 Hz and 300 Hz tone recorded in the environmental chamber from the same section of data on channels 1-13. The tone, recorded on channel 1, is at least 50 dB above the noise floor. On channels 2,3,5,7,8,11,12, and 13 there is some evidence of the 50 Hz tone, and on channels 3, 7, 8, 9, 11, 12, and

FIGURE 57

CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 124:10:52

CHANNEL 1



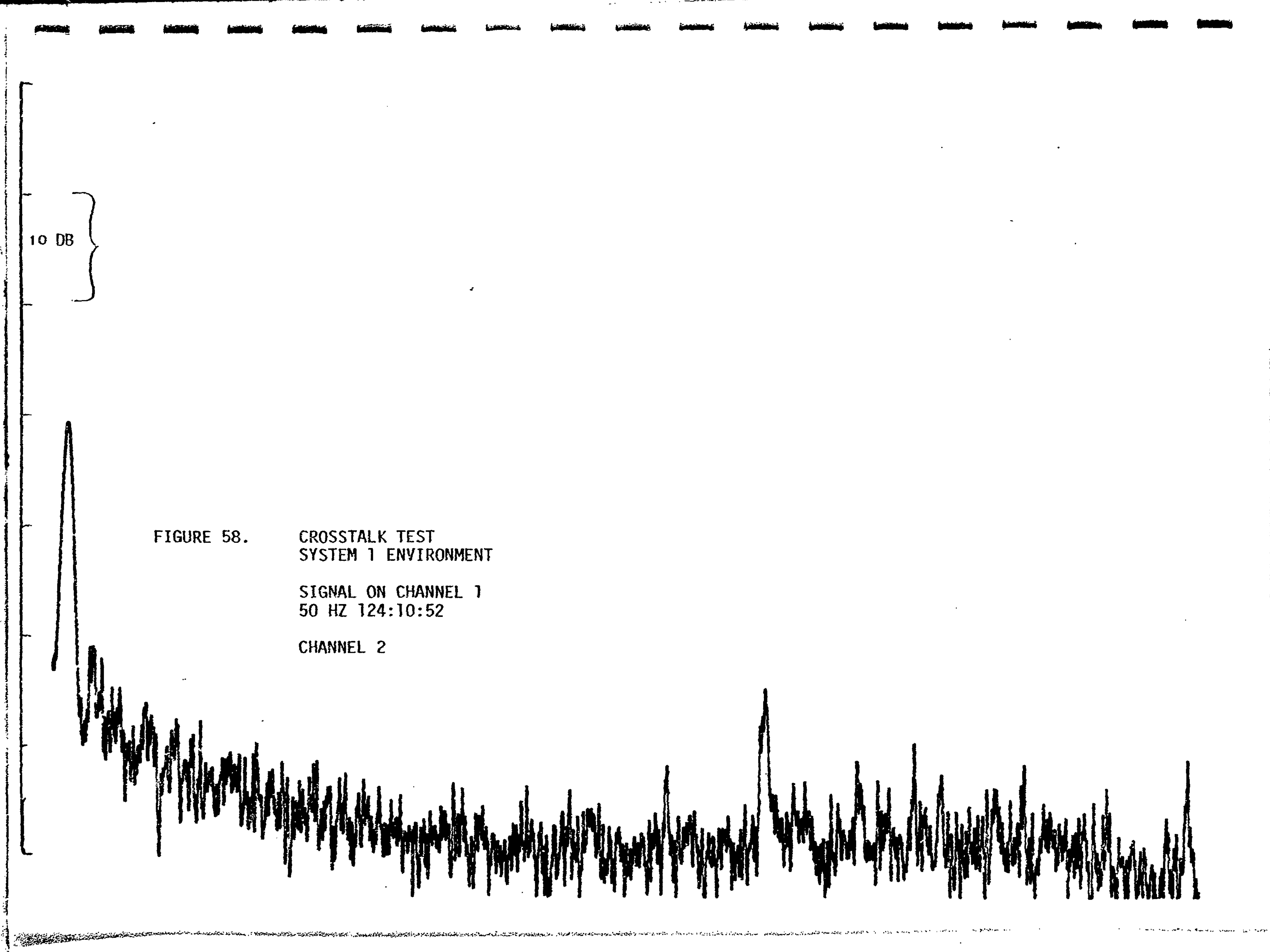


FIGURE 58. CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 124:10:52

CHANNEL 2

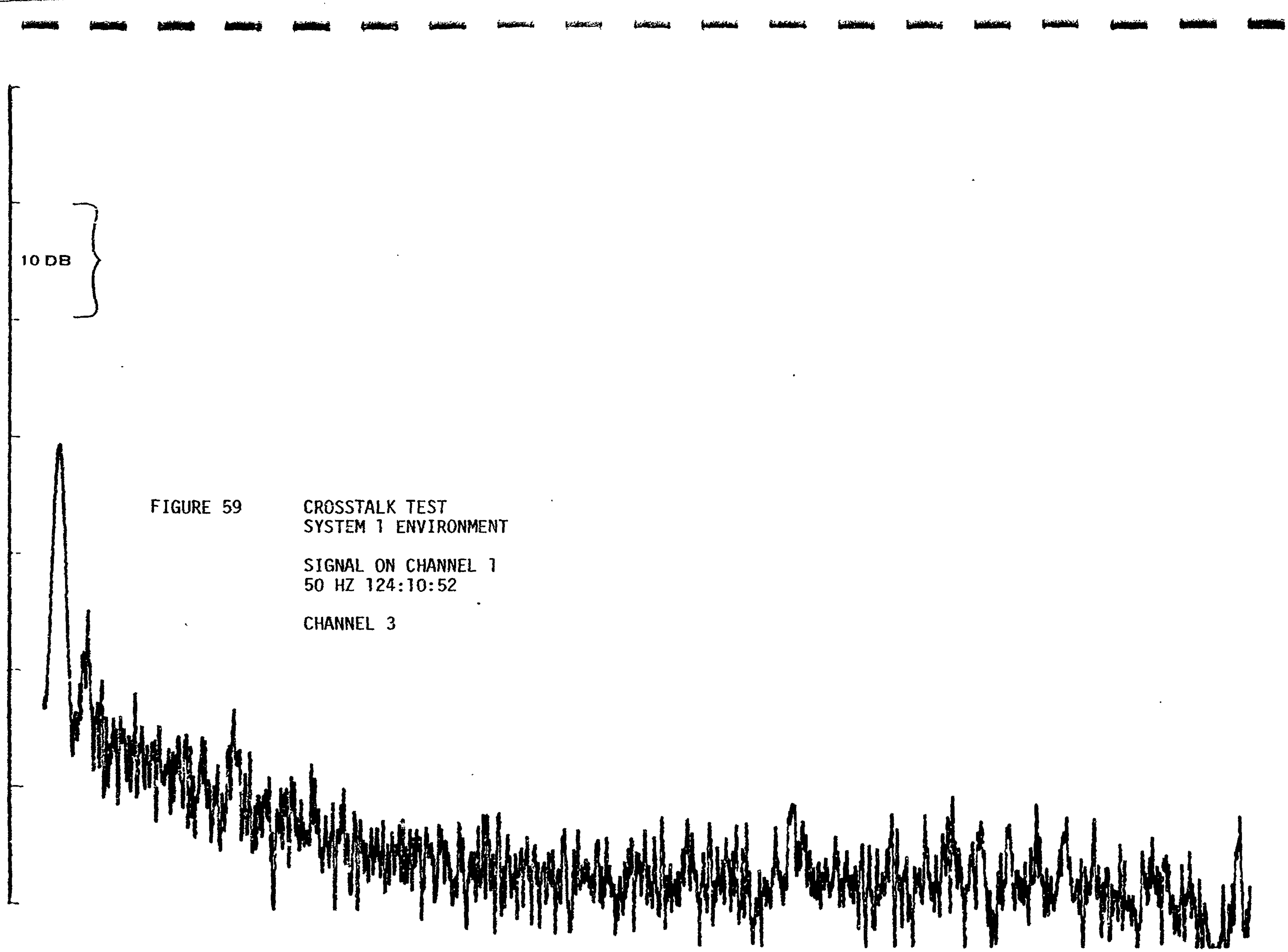


FIGURE 59 CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 124:10:52

CHANNEL 3

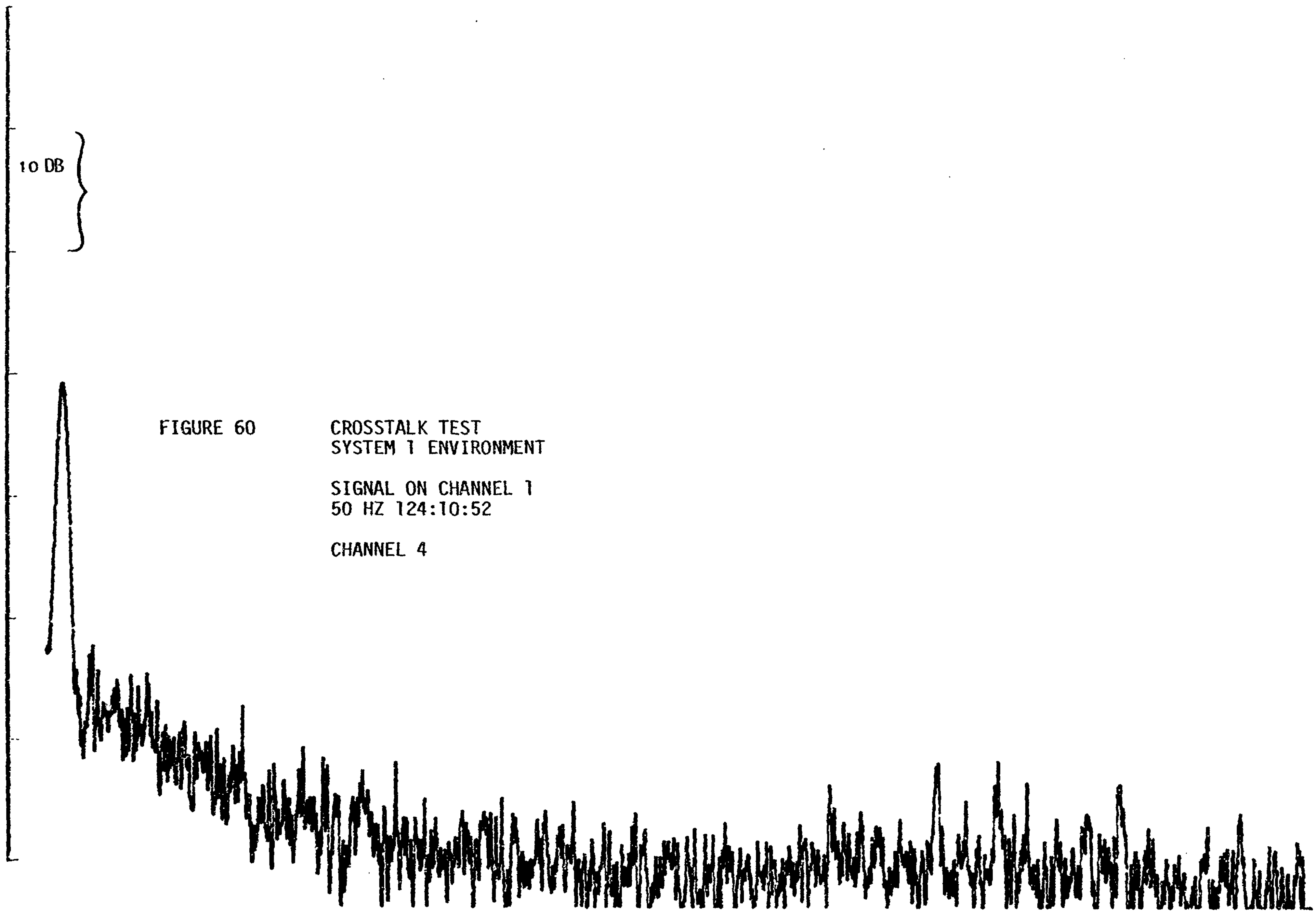


FIGURE 60 CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 124:10:52

CHANNEL 4

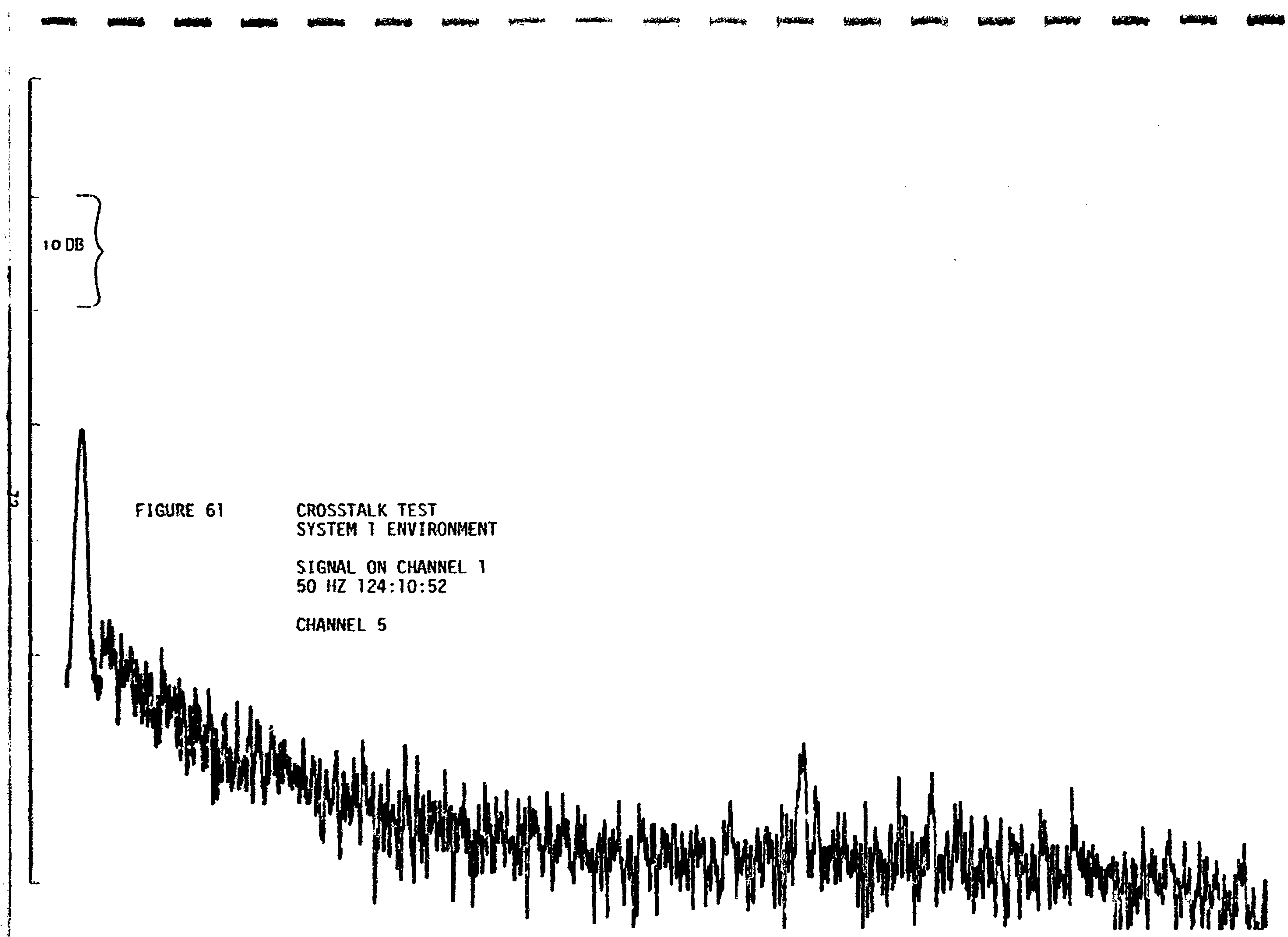


FIGURE 61 CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 124:10:52

CHANNEL 5

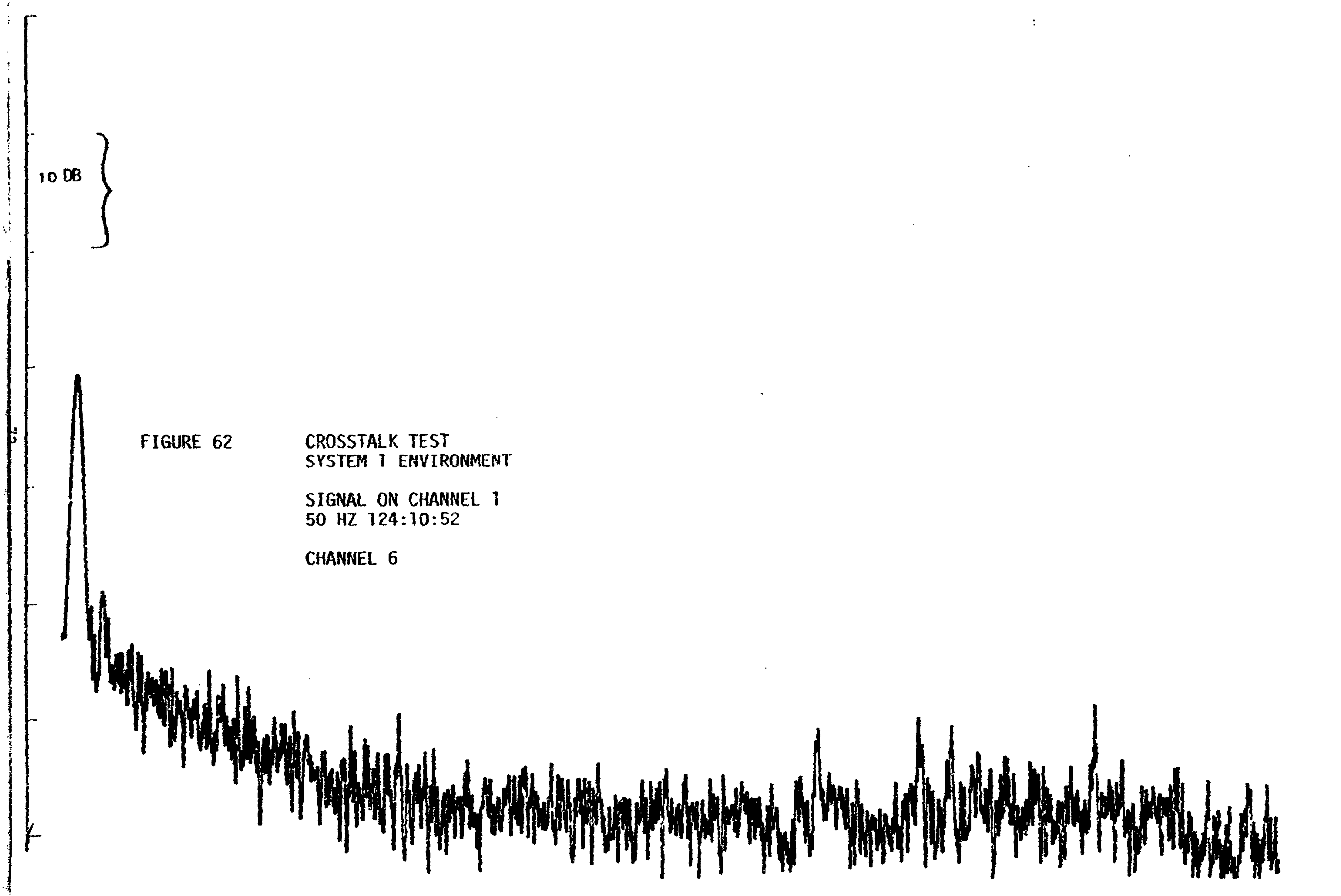
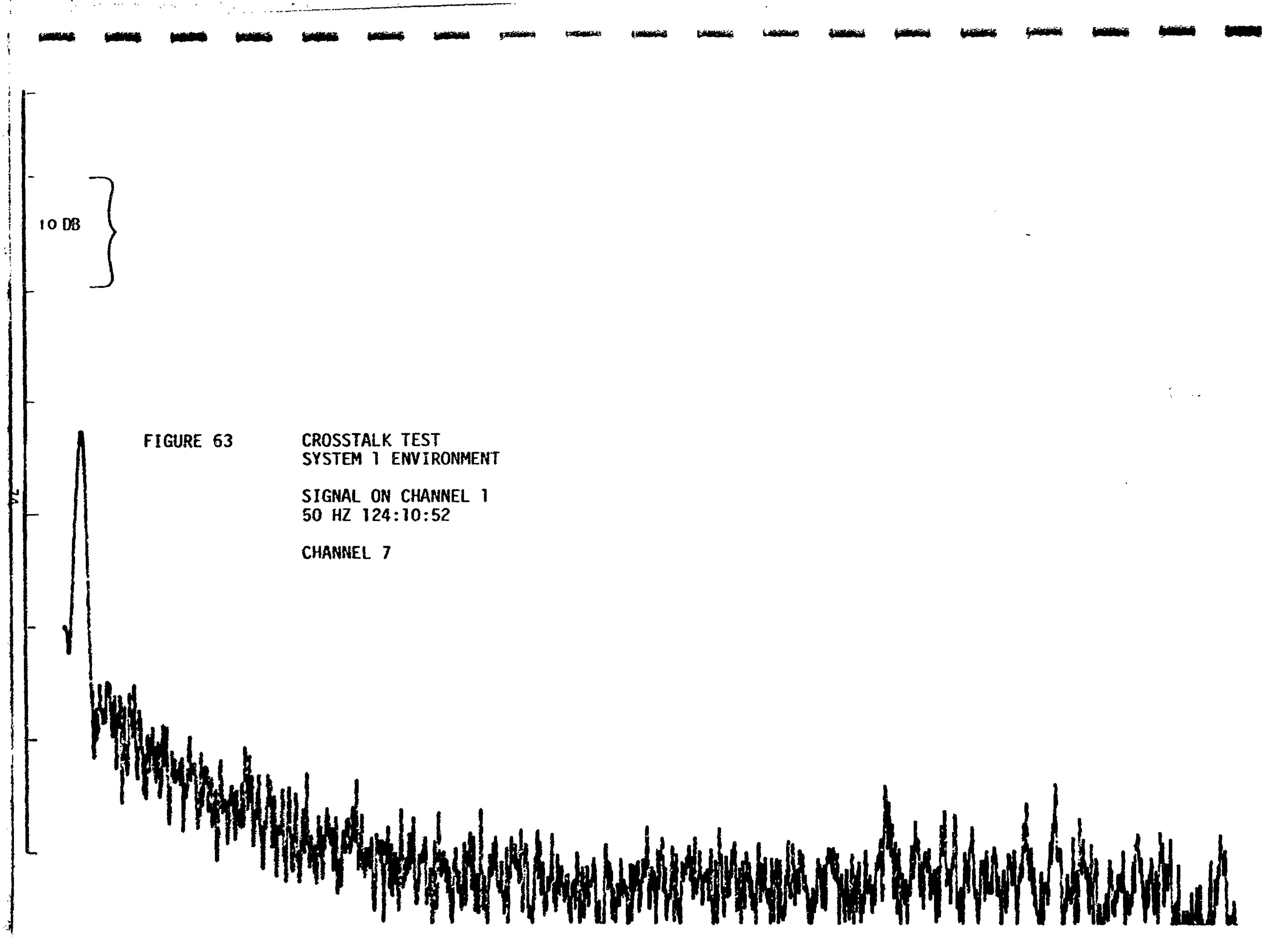

10 DB
CROSSTALK TEST
SYSTEM 1 ENVIRONMENT
SIGNAL ON CHANNEL 1
50 HZ 124:10:52
CHANNEL 6

FIGURE 62


10 DB
FIGURE 63
CROSSTALK TEST
SYSTEM 1 ENVIRONMENT
SIGNAL ON CHANNEL 1
50 HZ 124:10:52
CHANNEL 7

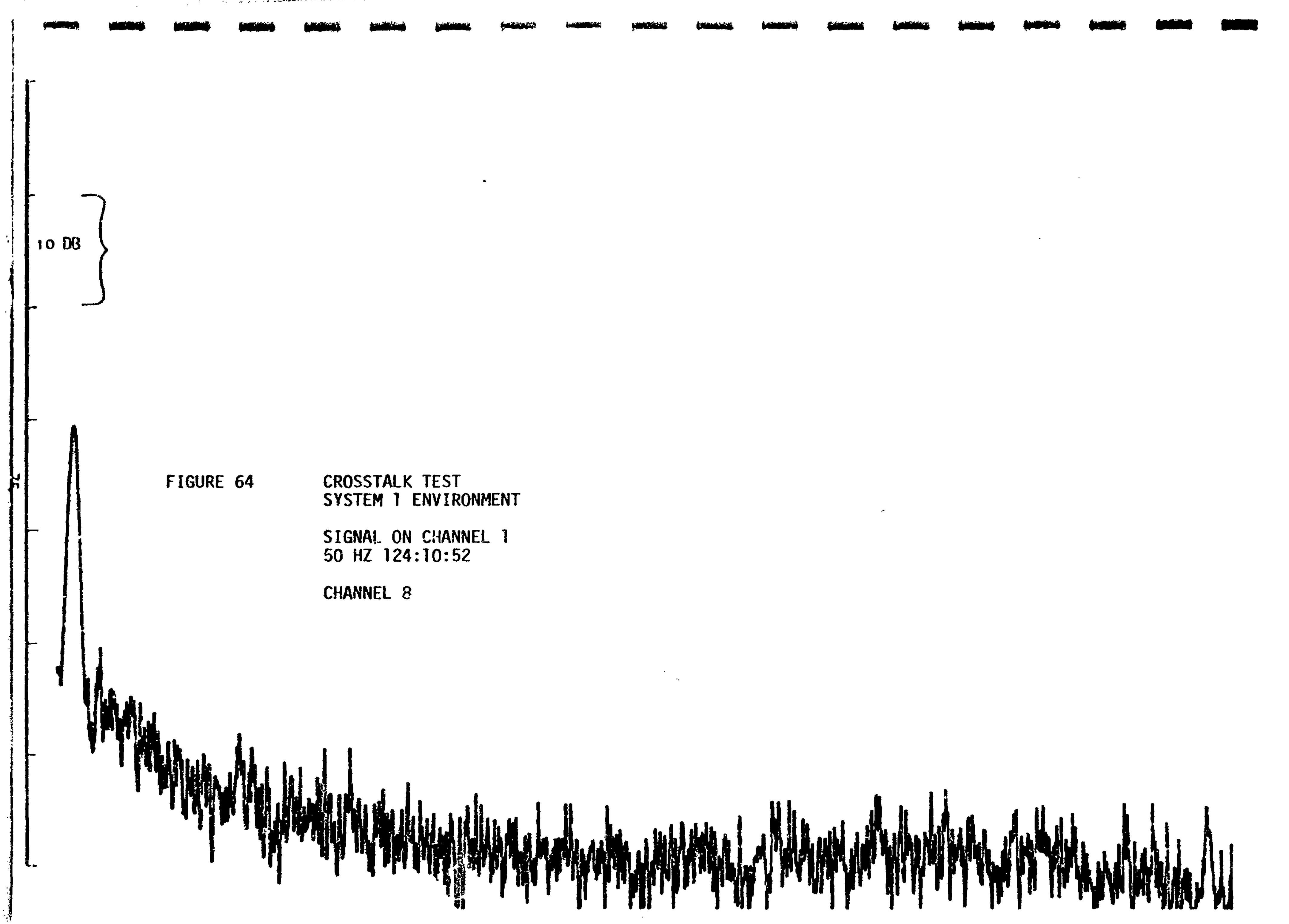


FIGURE 64 CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 124:10:52

CHANNEL 8

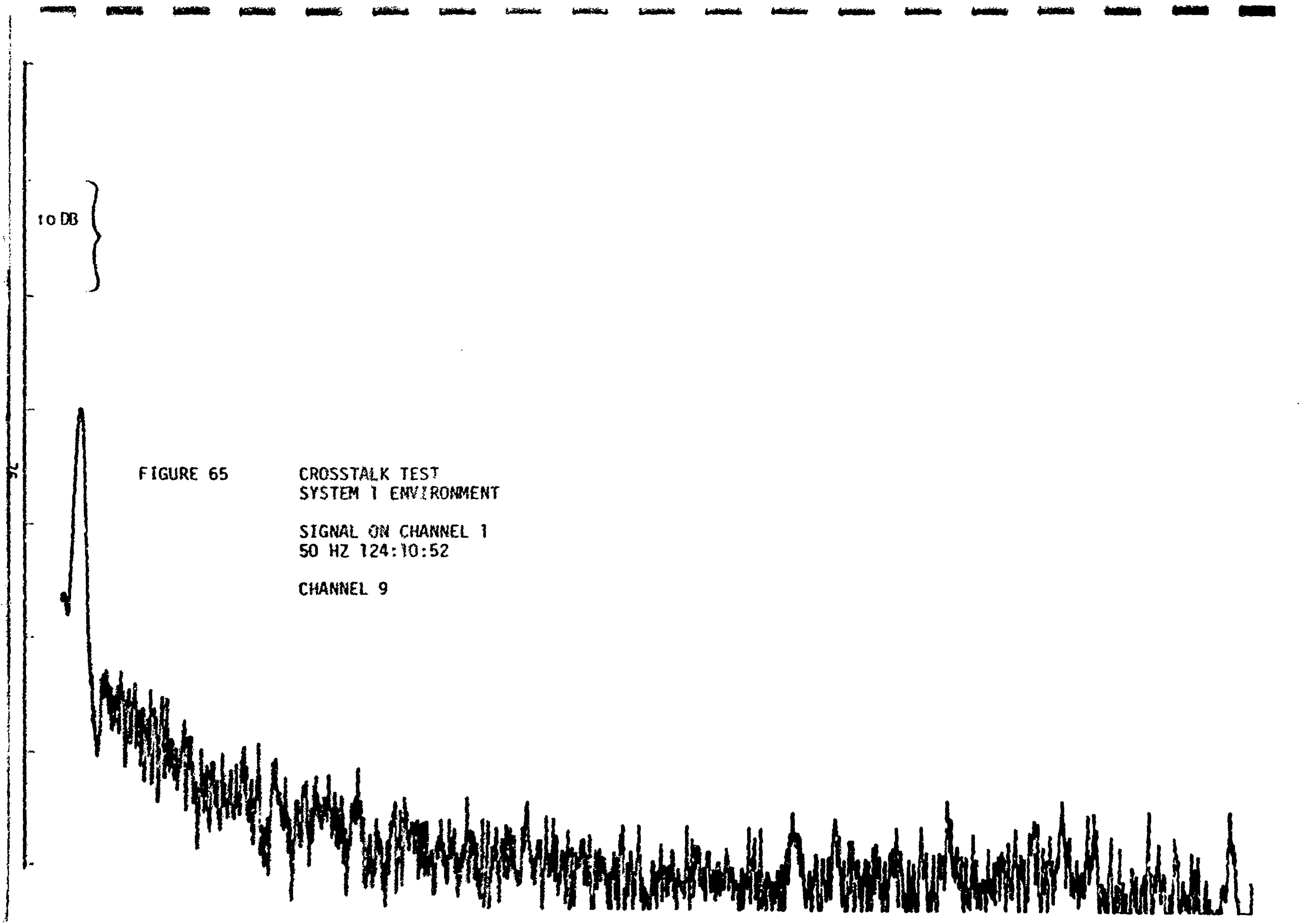


FIGURE 65 CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 124:10:52

CHANNEL 9

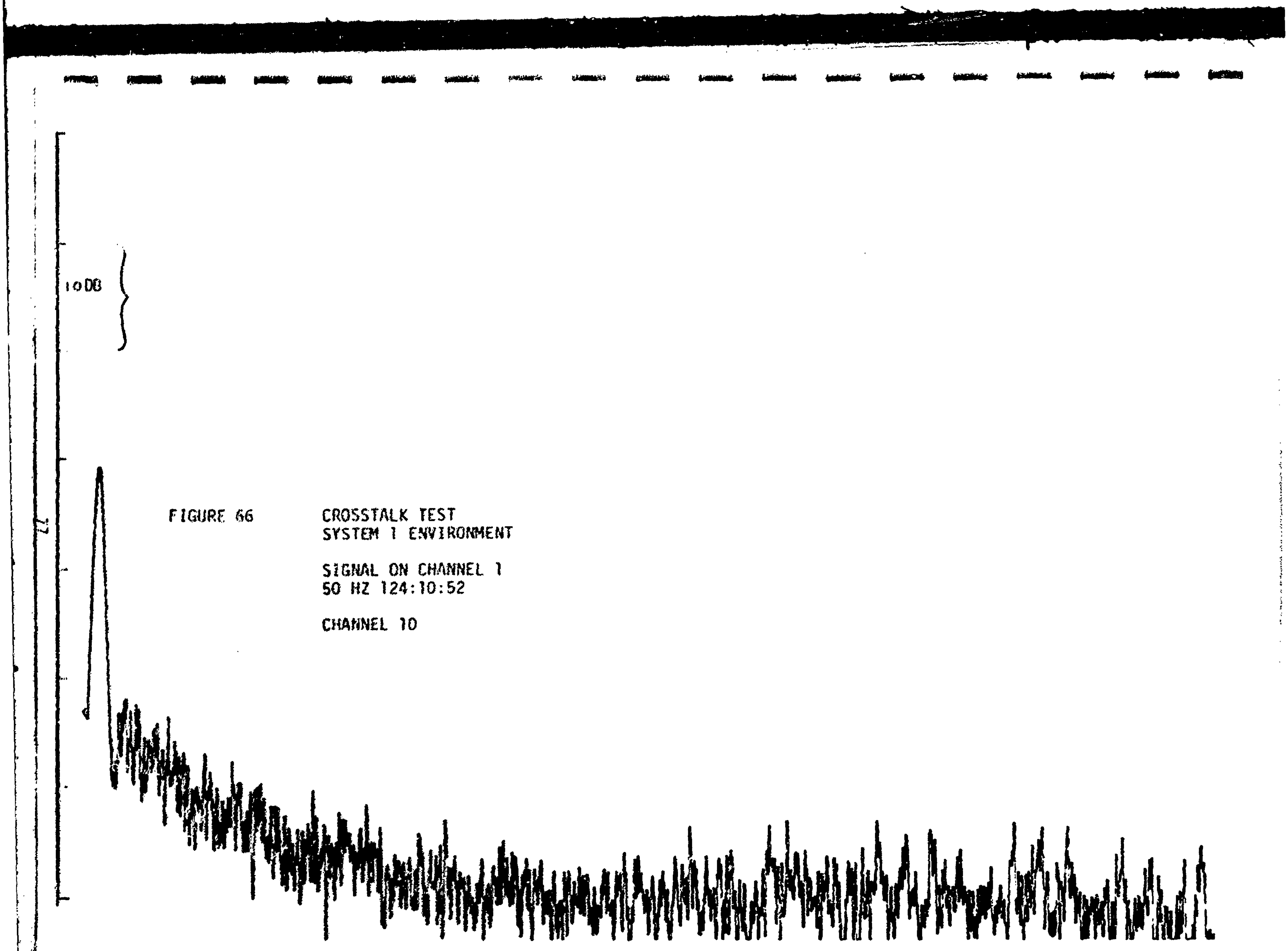
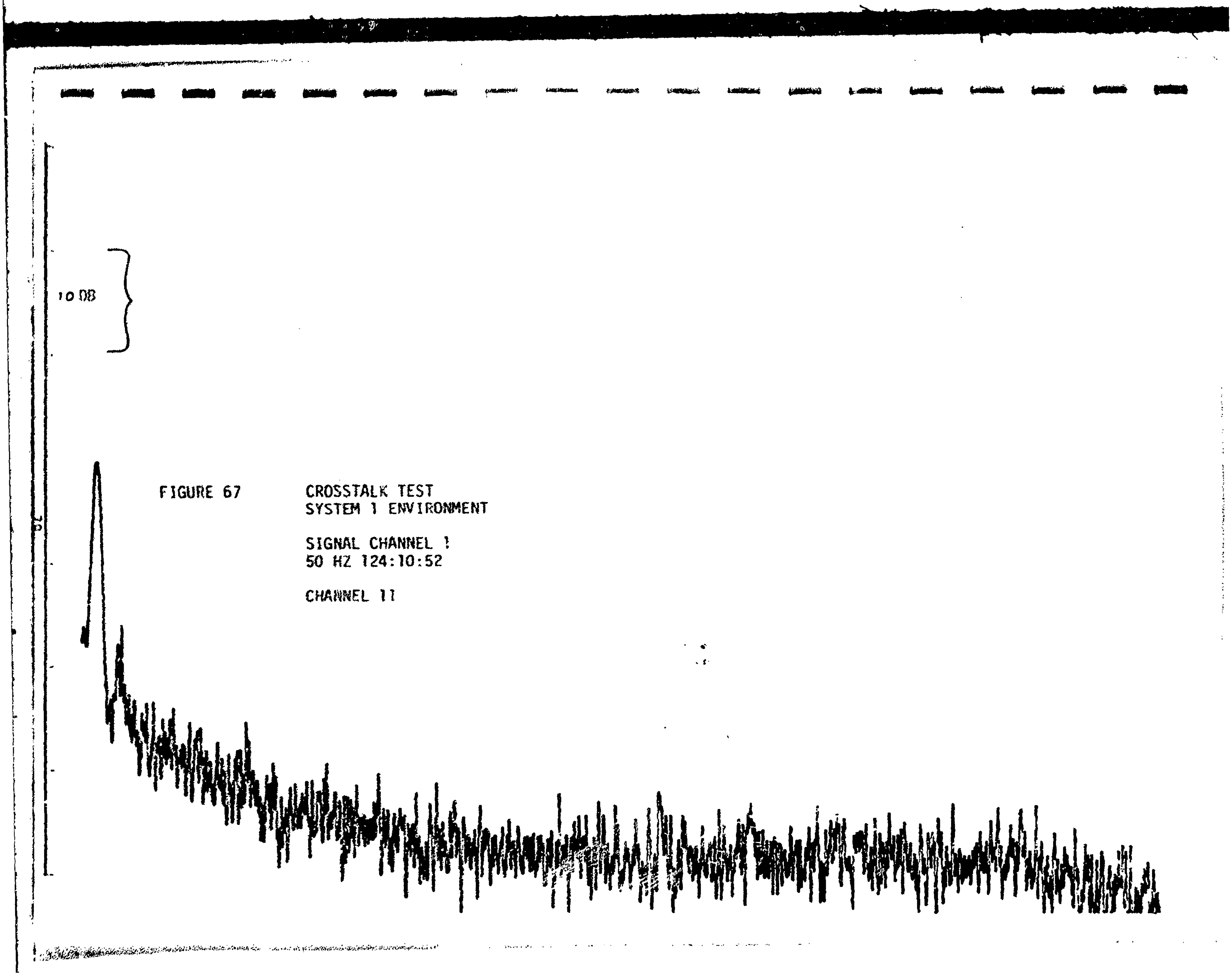
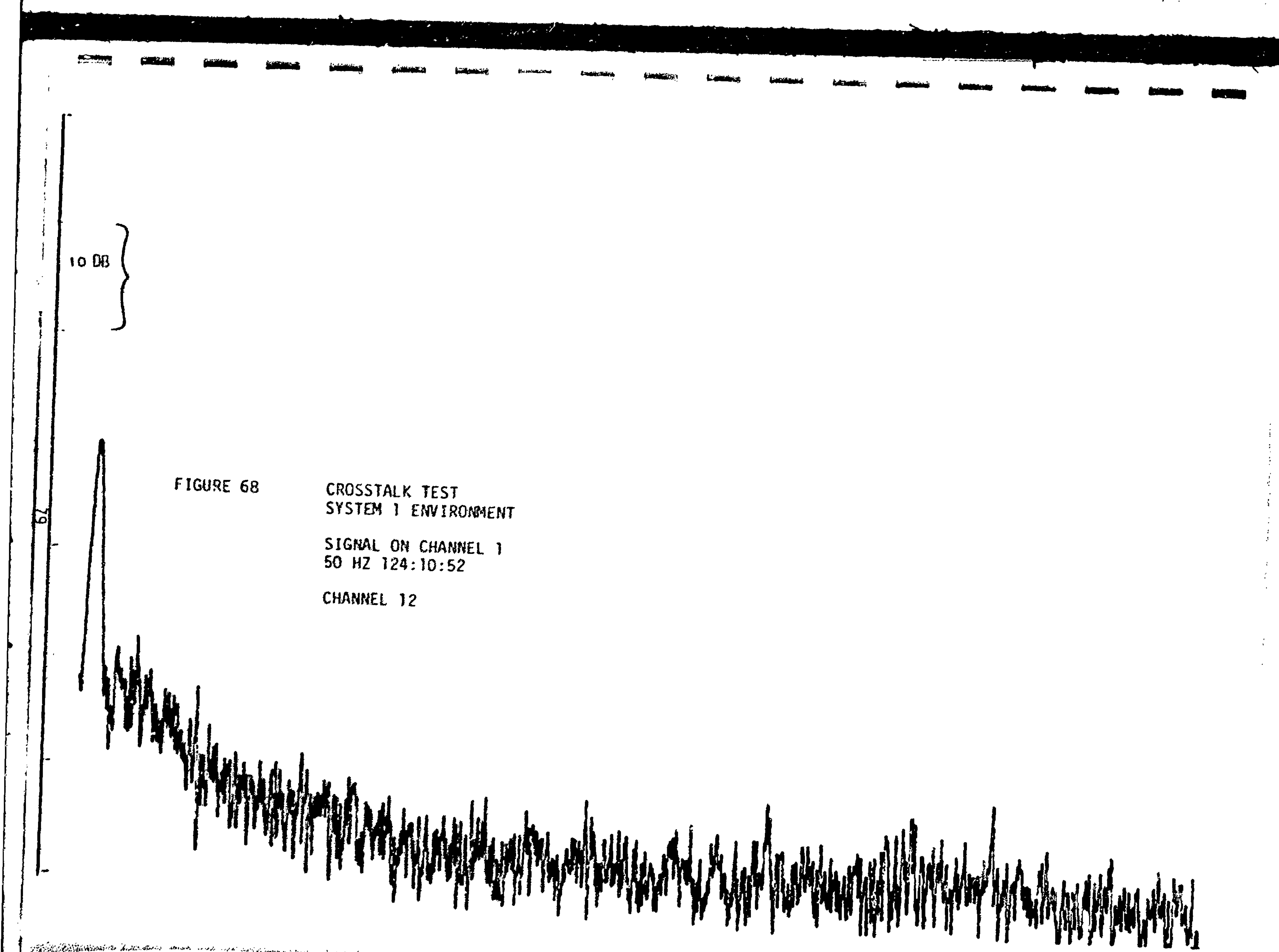


FIGURE 66 CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 124:10:52

CHANNEL 10


10 DB
CROSSTALK TEST
SYSTEM 1 ENVIRONMENT
SIGNAL CHANNEL 1
50 HZ 124:10:52
CHANNEL 11
FIGURE 67


10 DB
FIGURE 68
CROSSTALK TEST
SYSTEM 1 ENVIRONMENT
SIGNAL ON CHANNEL 1
50 HZ 124:10:52
CHANNEL 12

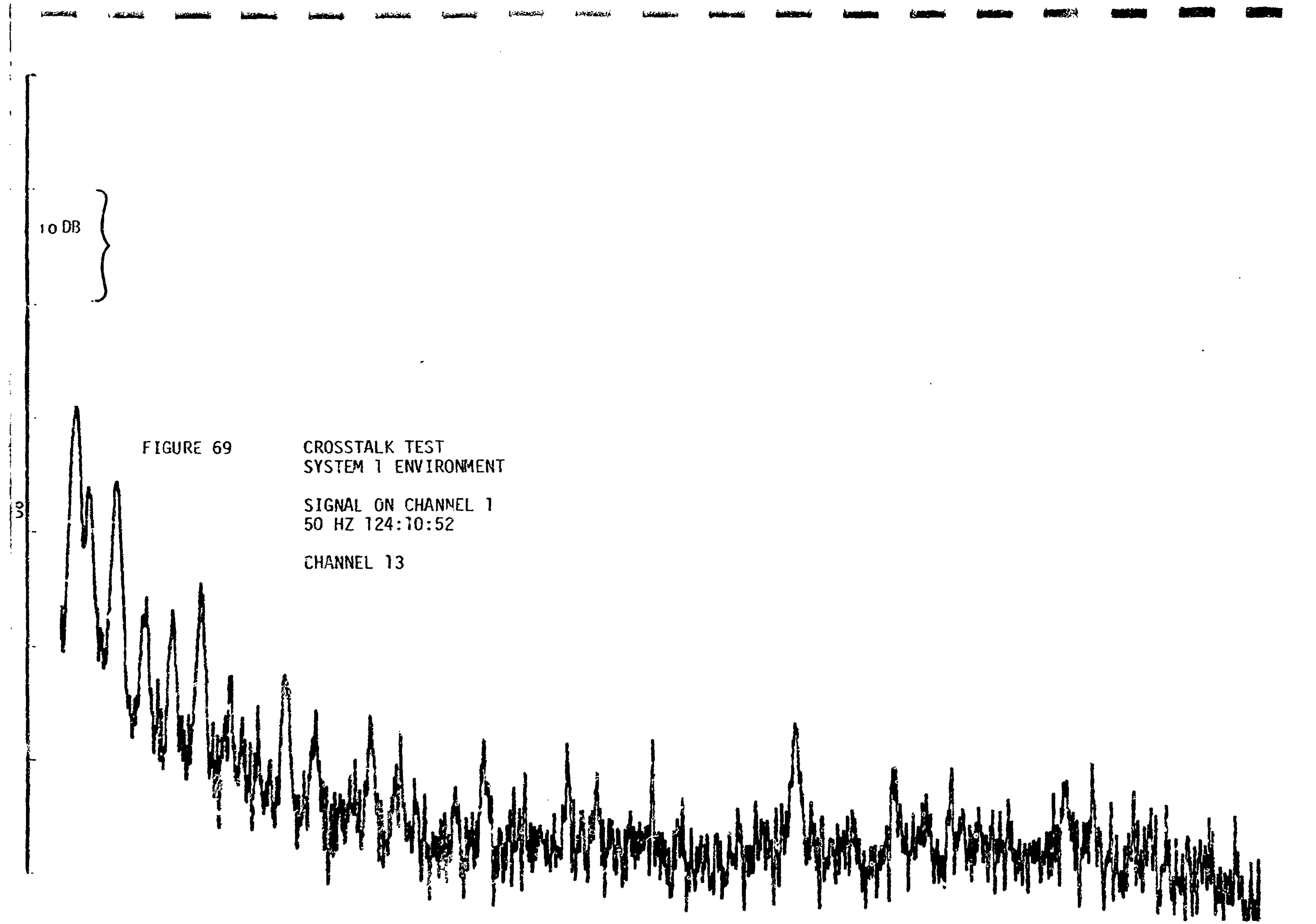


FIGURE 69 CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 124:10:52

CHANNEL 13

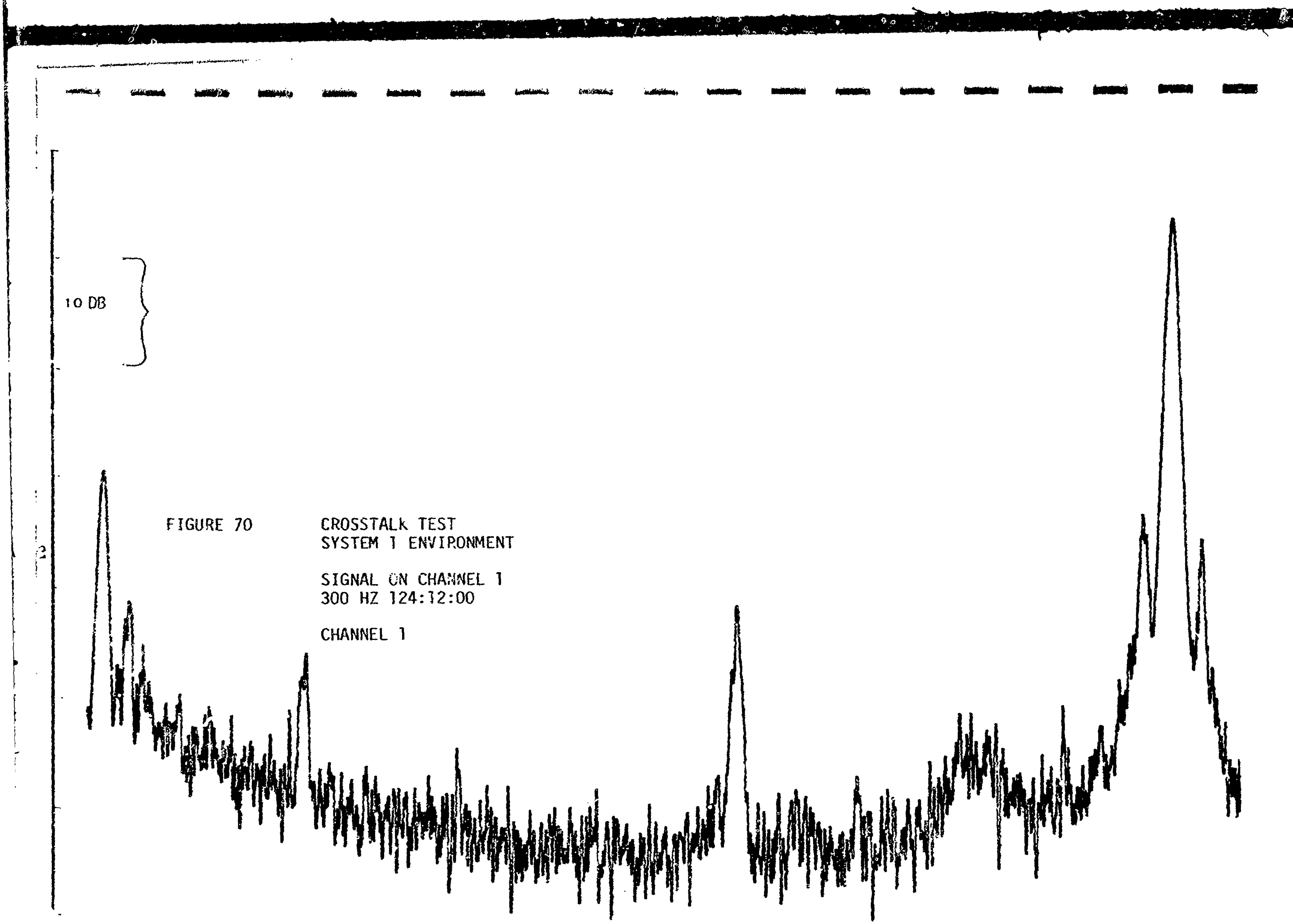


FIGURE 70

CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 124:12:00

CHANNEL 1

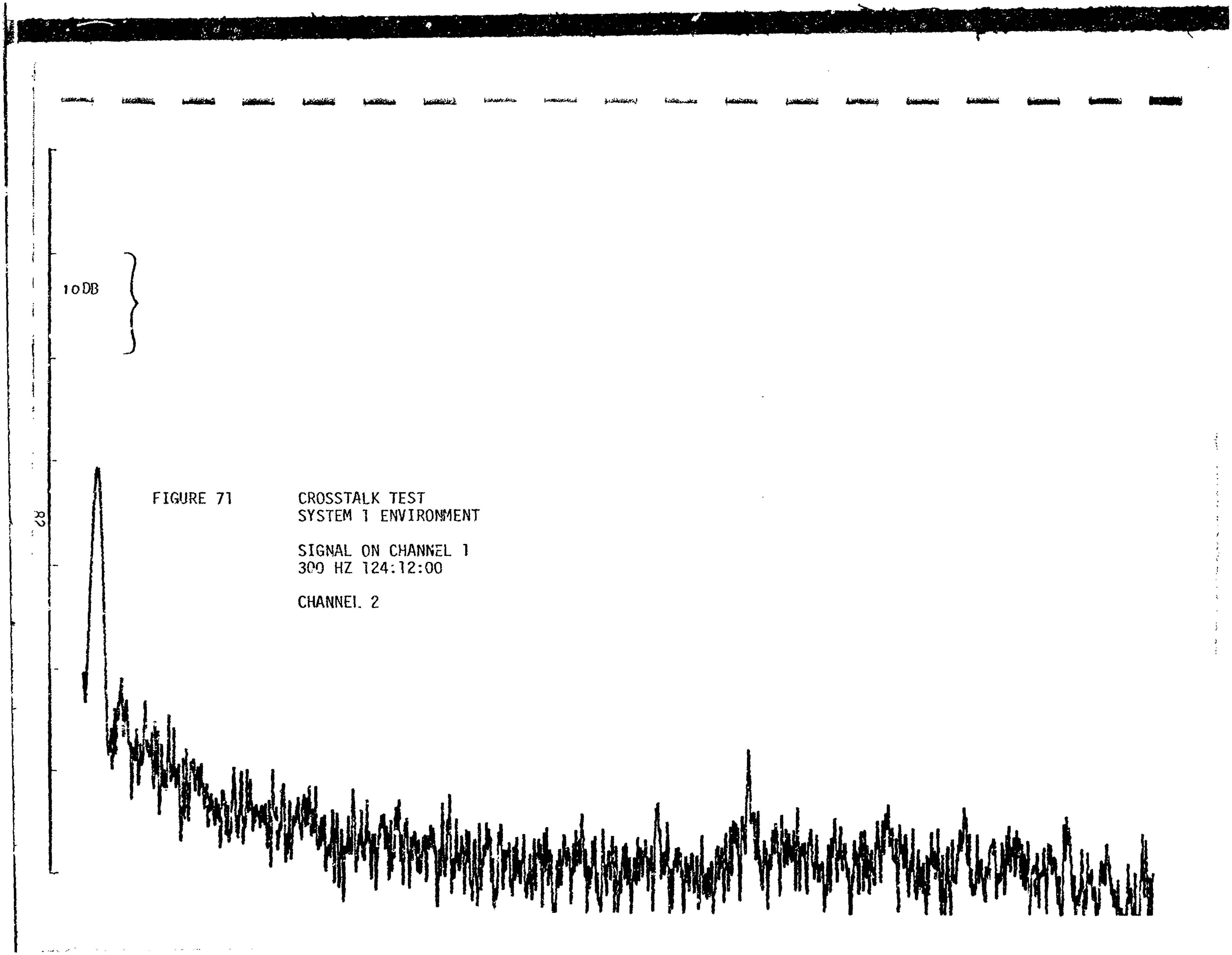


FIGURE 71 CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 124:12:00

CHANNEL 2

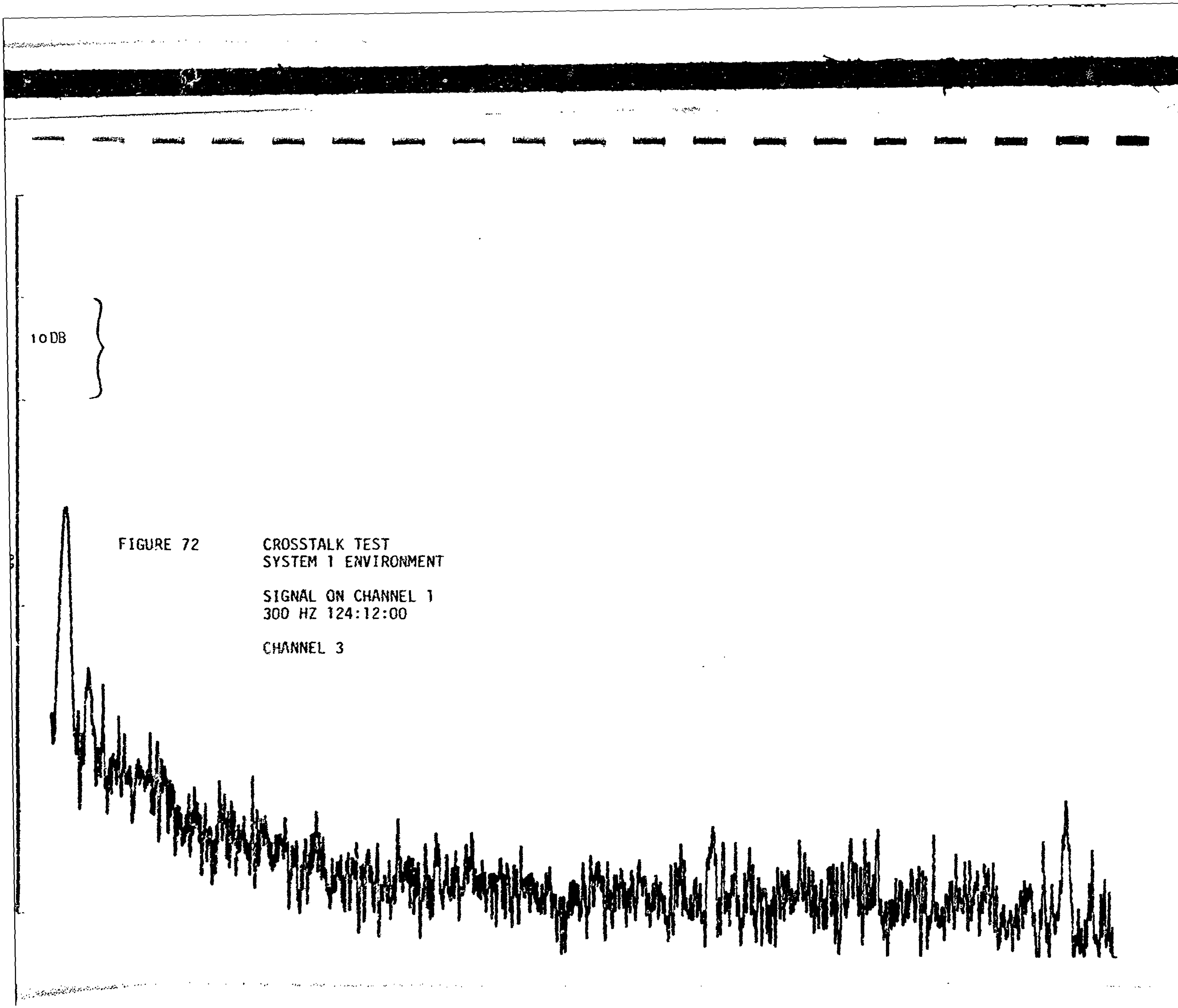


FIGURE 72 CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 124:12:00

CHANNEL 3

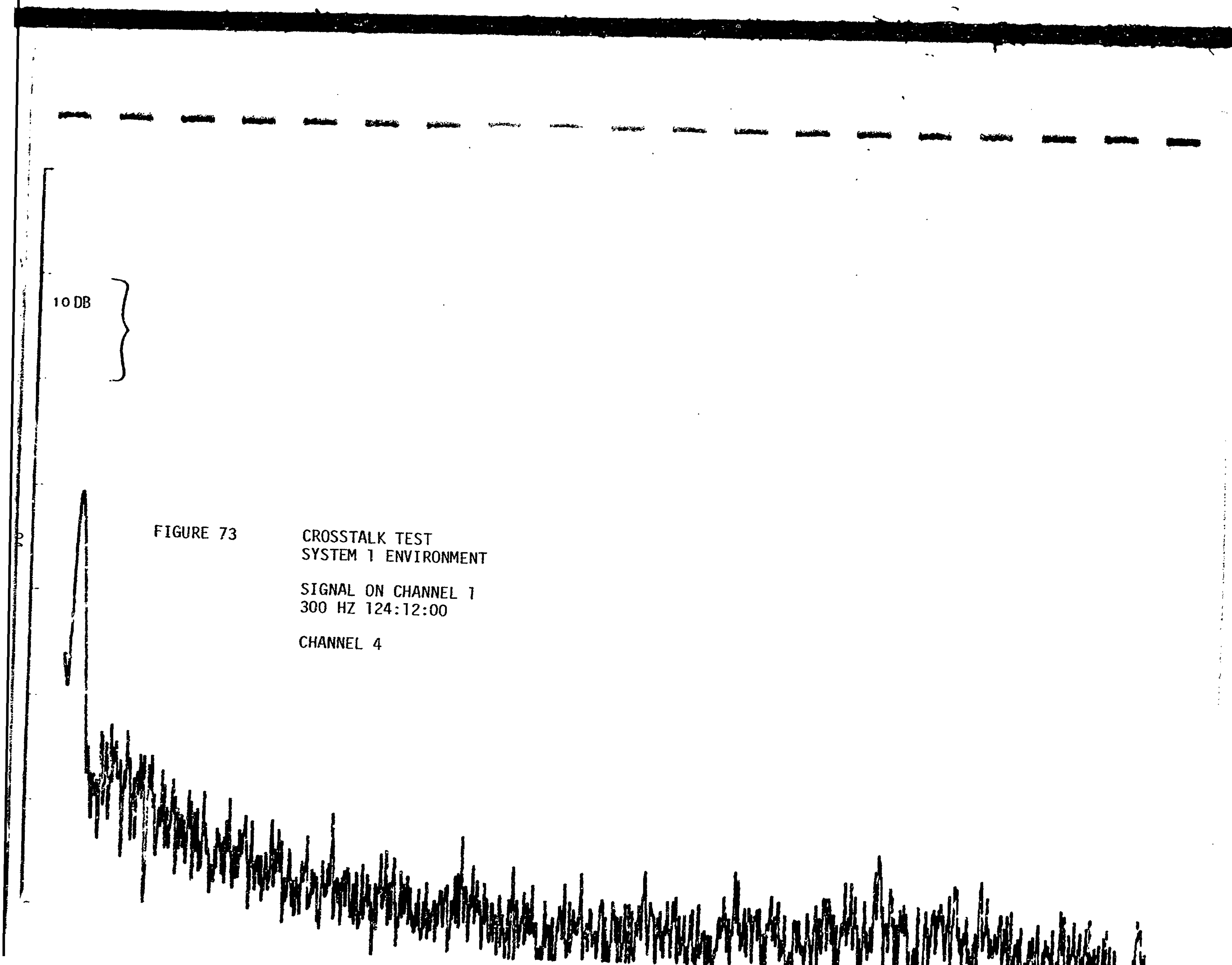


FIGURE 73 CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 124:12:00

CHANNEL 4

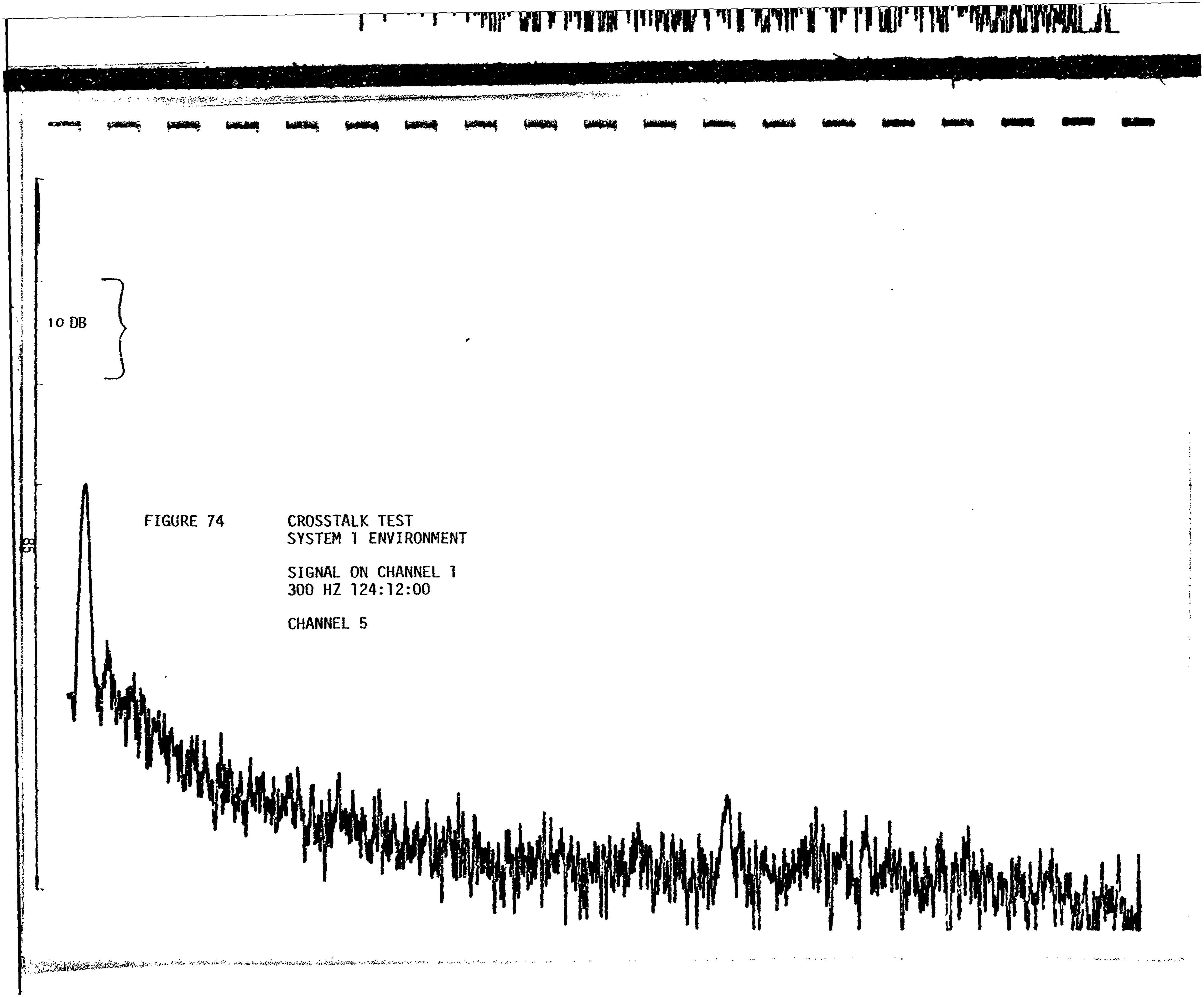


FIGURE 74 CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 124:12:00

CHANNEL 5

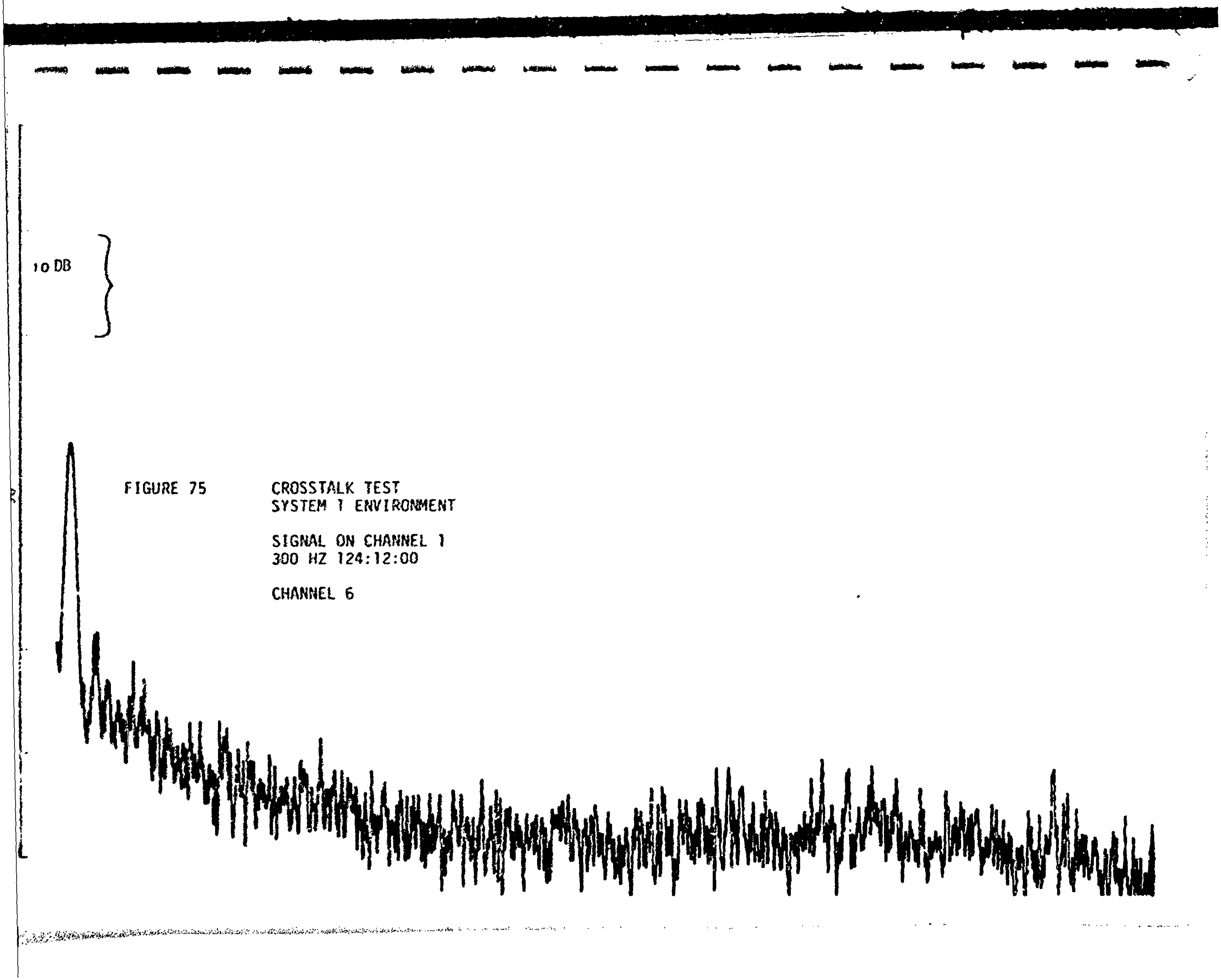

10 DB
CROSSTALK TEST
SYSTEM T ENVIRONMENT
SIGNAL ON CHANNEL 1
300 HZ 124:12:00
CHANNEL 6

FIGURE 75

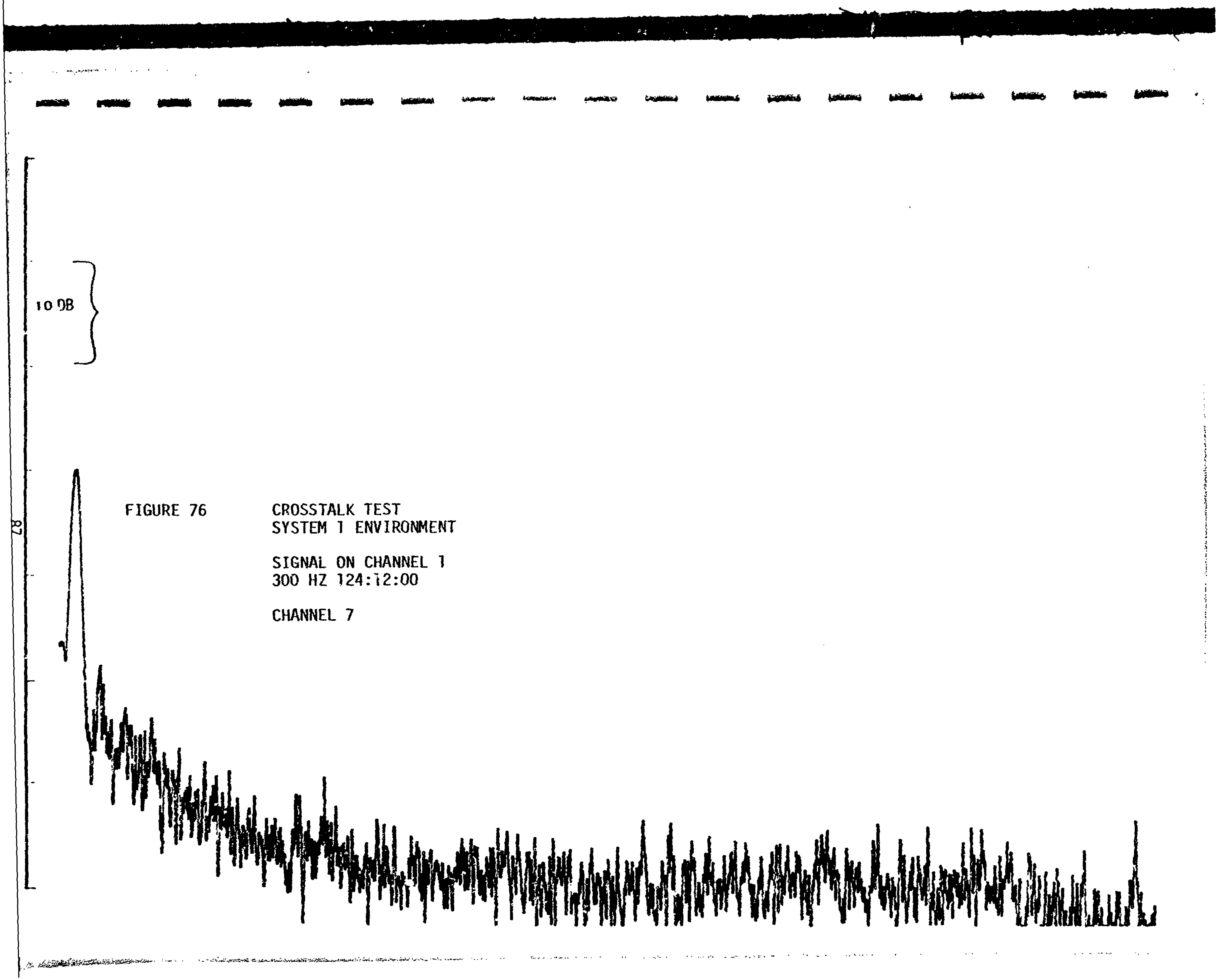


FIGURE 76 CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 124:12:00

CHANNEL 7

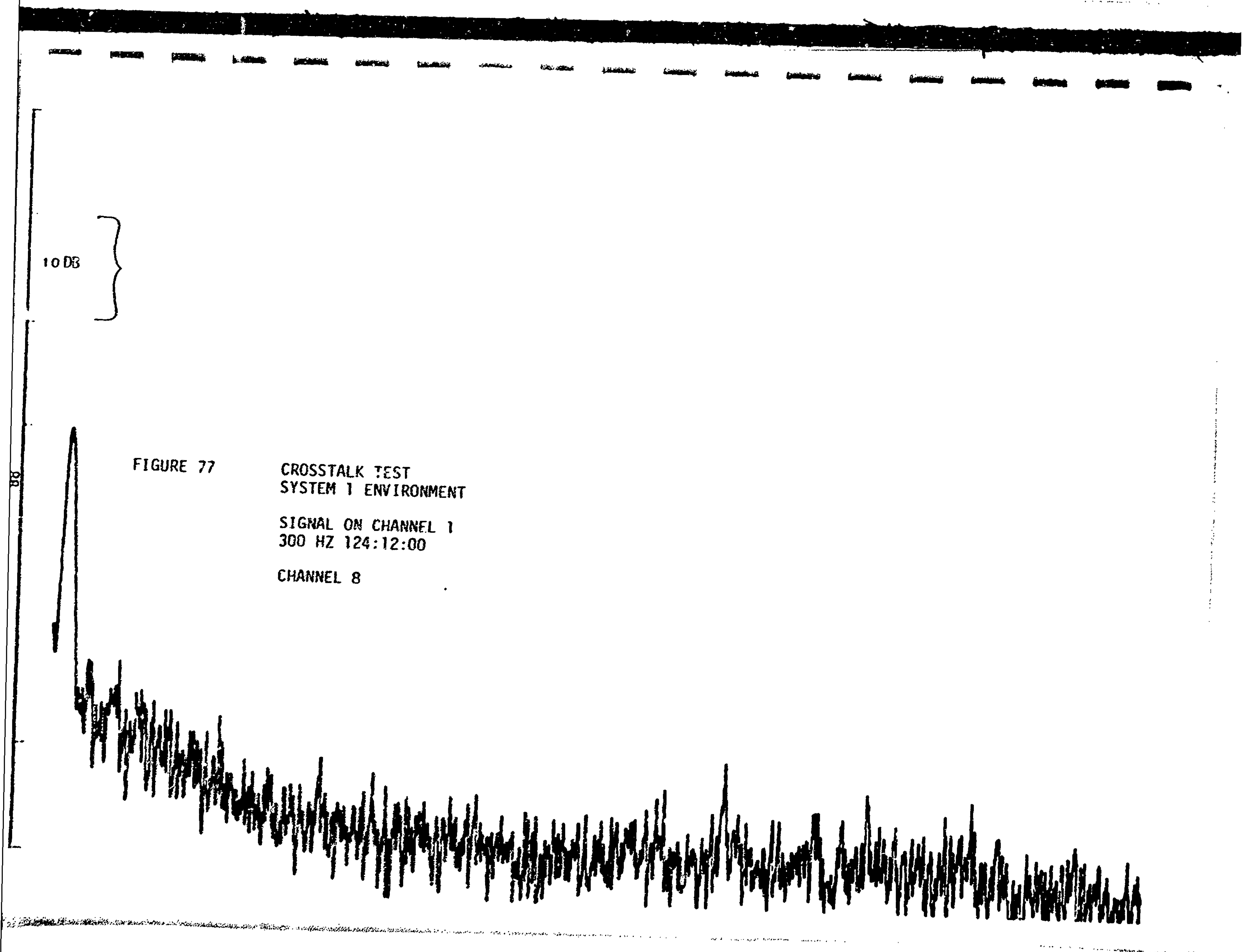


FIGURE 77

CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 124:12:00

CHANNEL 8

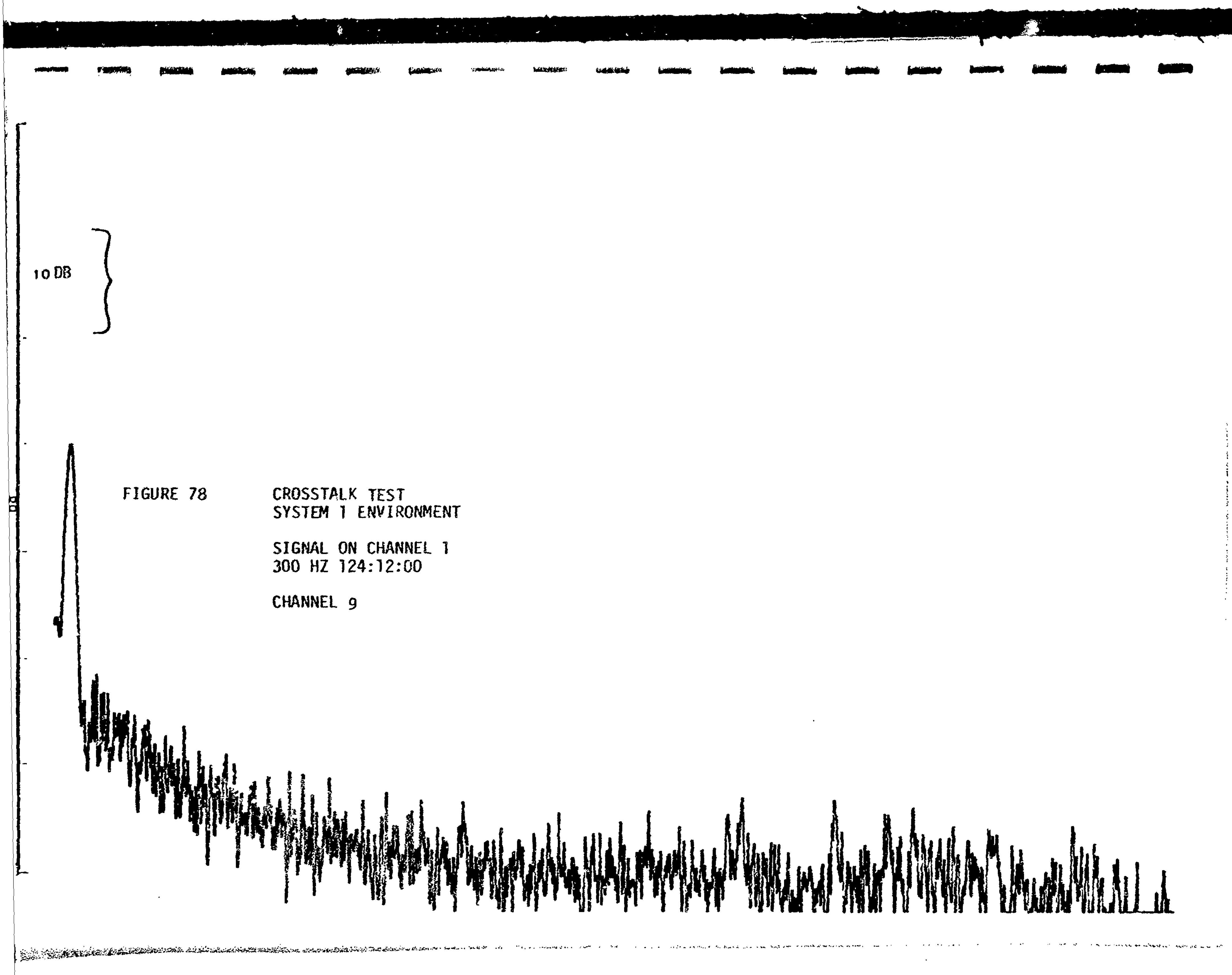
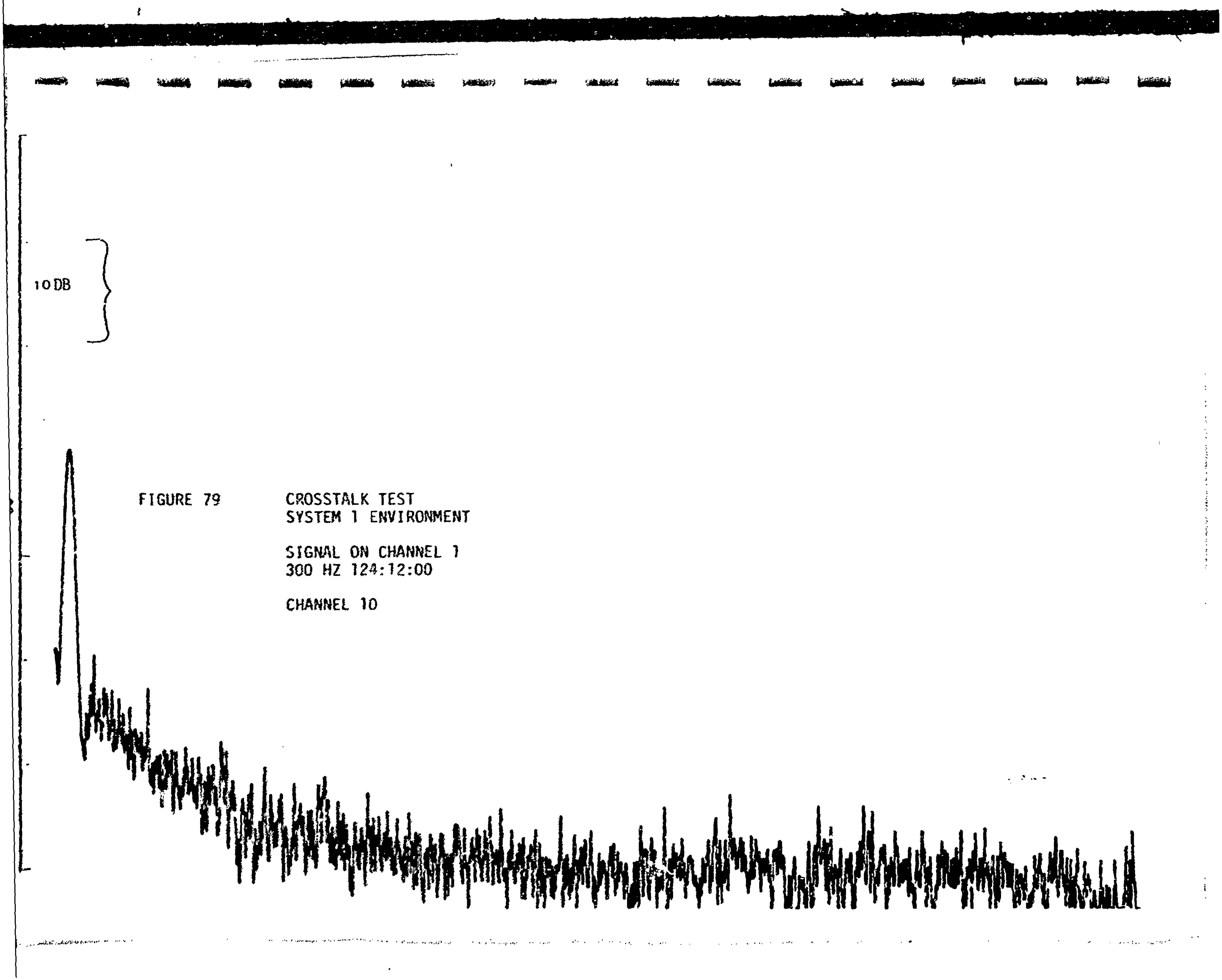


FIGURE 78 CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 124:12:00

CHANNEL 9


10 DB
FIGURE 79
CROSSTALK TEST
SYSTEM 1 ENVIRONMENT
SIGNAL ON CHANNEL 1
300 HZ 124:12:00
CHANNEL 10

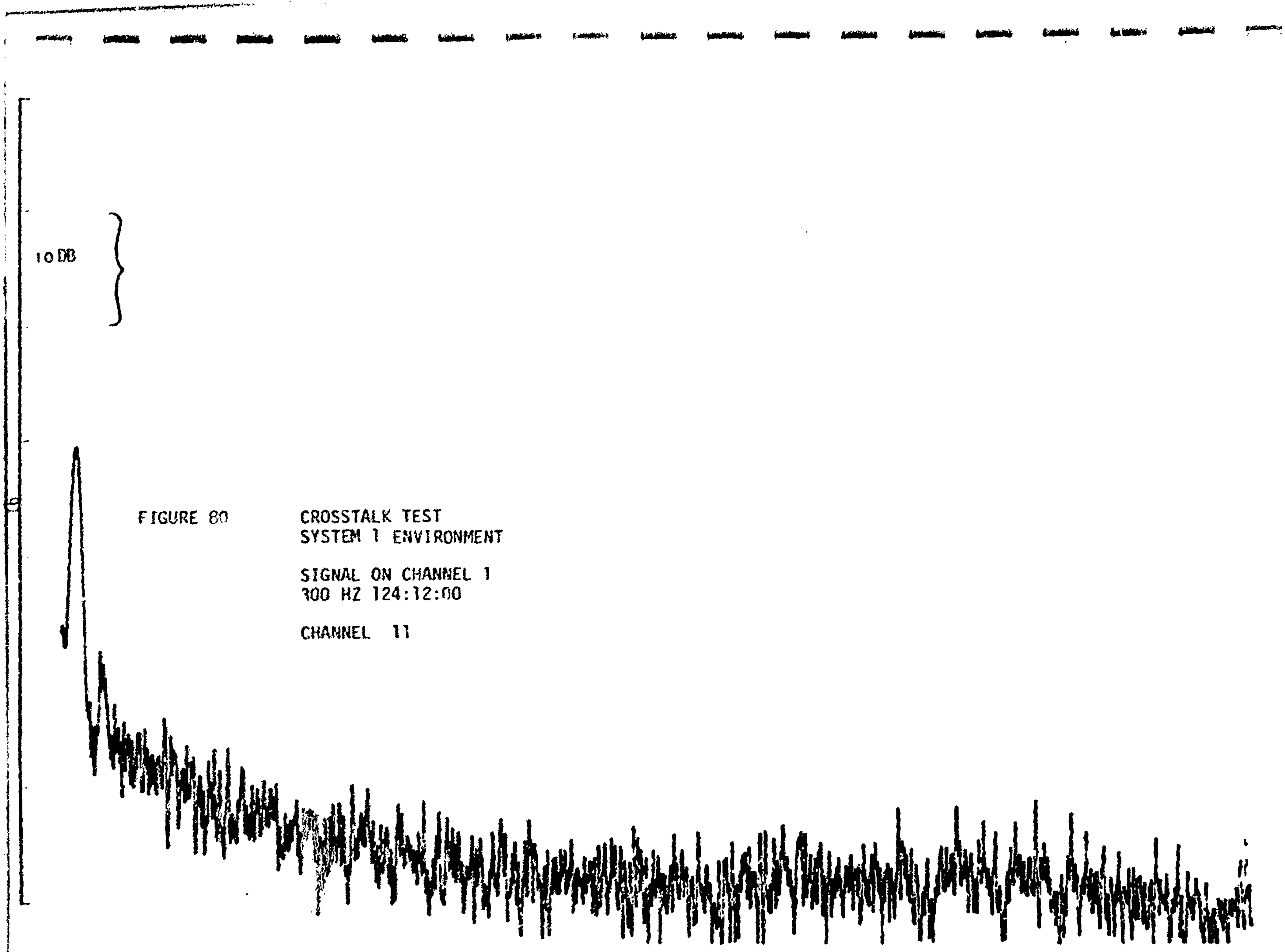
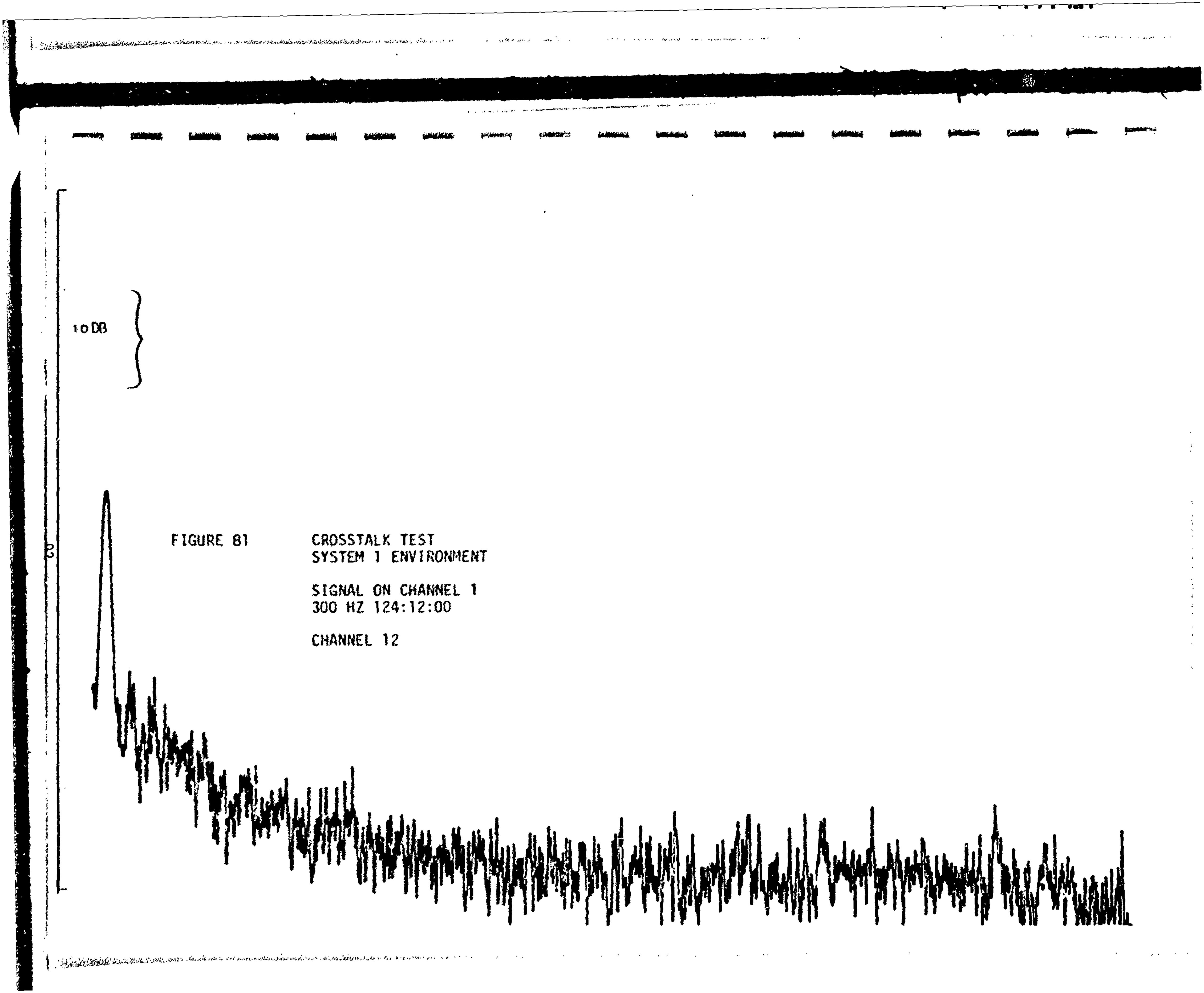


FIGURE 80 CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 124:12:00

CHANNEL 11


10DB
FIGURE 81
CROSSTALK TEST
SYSTEM 1 ENVIRONMENT
SIGNAL ON CHANNEL 1
300 HZ 124:12:00
CHANNEL 12

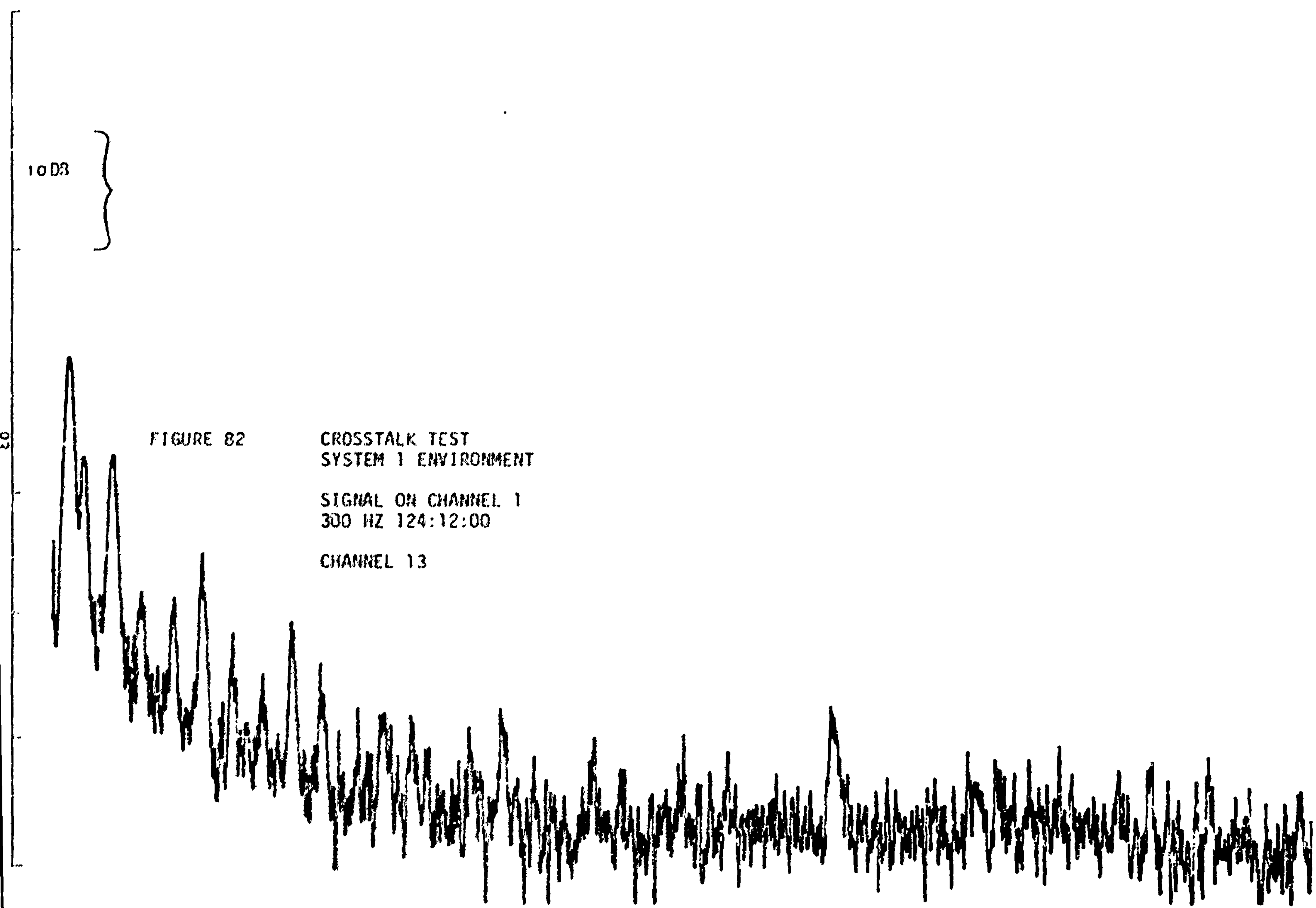


FIGURE 82 CROSSTALK TEST
SYSTEM 1 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 124:12:00

CHANNEL 13

13 there is some evidence of the 300 Hz tone. In all cases the crosstalk component is at least 50 dB below the primary tone and no more than 5 dB above the noise floor. Similar results were noted when the signals were recorded on other channels; consequently, it can be concluded that the system crosstalk is better than 50 dB below the normal record level.

c. System 2

Figures 83 through 108 show the spectra of the 50 Hz and 300 Hz tone recorded in the environmental chamber from the same section of data on channels 1-13. The tones which were recorded on channel 1 are at least 50 dB above the noise floor. Some evidence of the 50 Hz tone is seen to be leaking into channels 3, 4, 8, and 11. The 300 Hz tone may be leaking into channels 3 and 6. In all cases these crosstalk tones are at least 50 dB below the primary tone on channel 1 and no more than 7 dB above the noise floor of the particular channel. Similar results were obtained from data samples recorded on channels 2-13. Again, as with system 1, it can be concluded that crosstalk is better than 50 dB below the normal record level.

8. Intermodulation Distortion

a. Data Recorded

Two sine waves of 20 Hz and 110 Hz with equal amplitudes and whose composite amplitude is -10 dB were recorded with the data amplifier gain set to 0 dB.

b. System 1

Since all data recorded in system 1 was contaminated by the problem in the pre-emphasis circuit, no direct determination of intermodulation distortion could be made. The magnitude of the sum and difference components can only be inferred from the characteristics of system 2 as described in paragraph c. below.

c. System 2

Figures 109 and 110 show the spectra of the intermodulation distortion data recorded under laboratory conditions on channel 13. Inspection of these spectra does not reveal any significant sum or difference component. Any intermodulation, if it exists, is buried in the noise and does not appear in the spectra of the tones recorded alone or mixed with white noise.

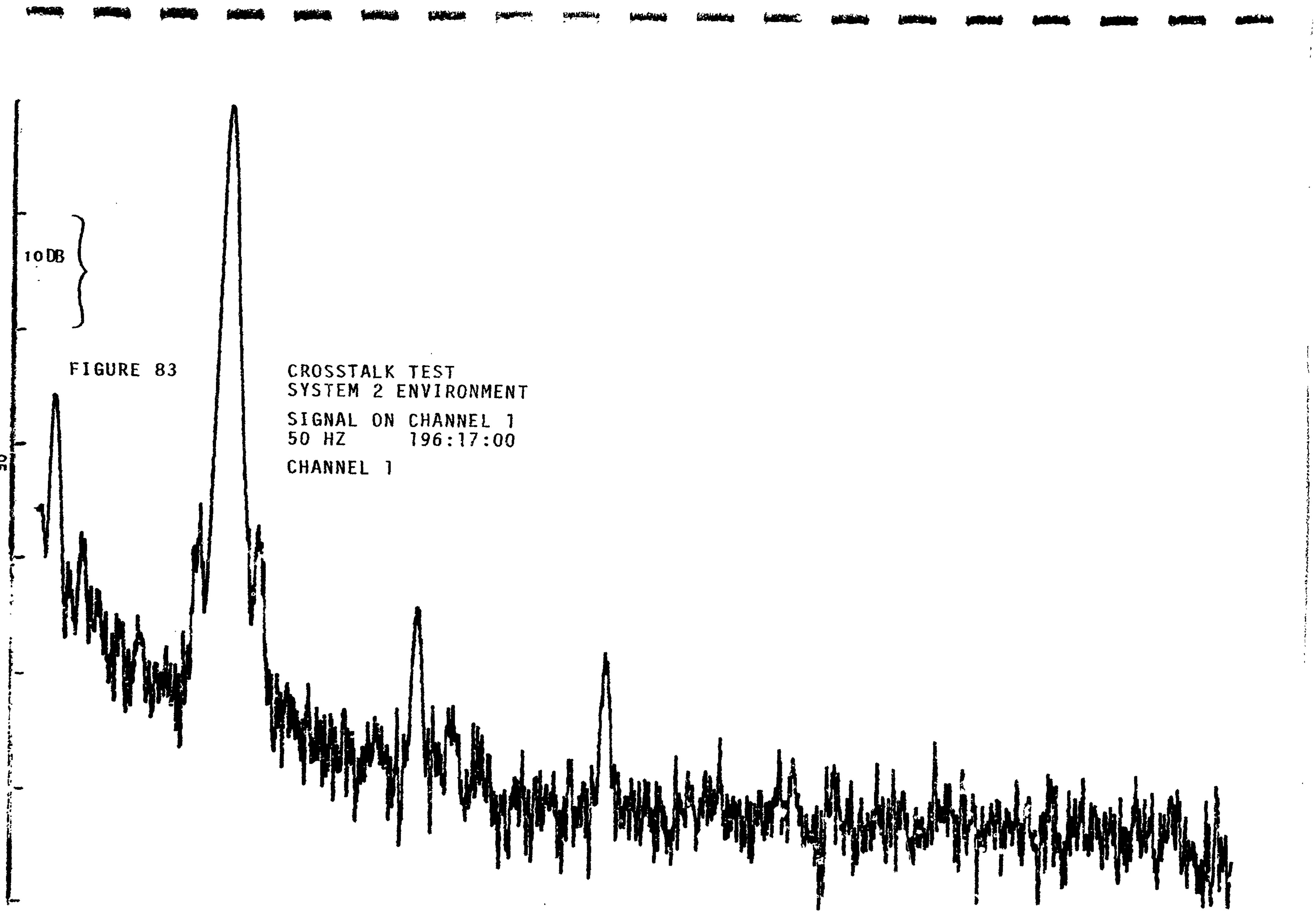

10DB
CROSSTALK TEST
SYSTEM 2 ENVIRONMENT
SIGNAL ON CHANNEL 1
50 HZ 196:17:00
CHANNEL 1

FIGURE 83

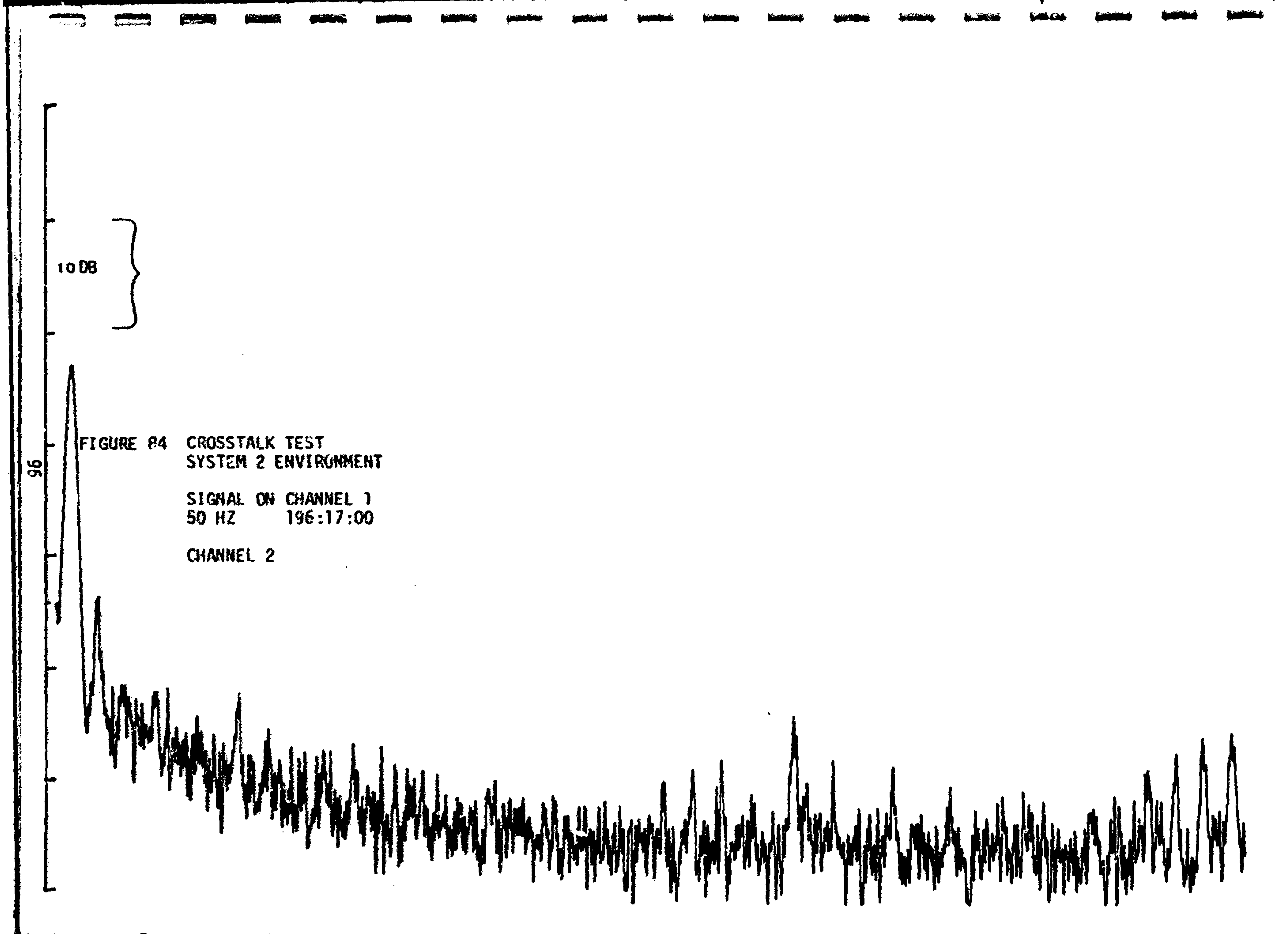


FIGURE 84 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 196:17:00

CHANNEL 2

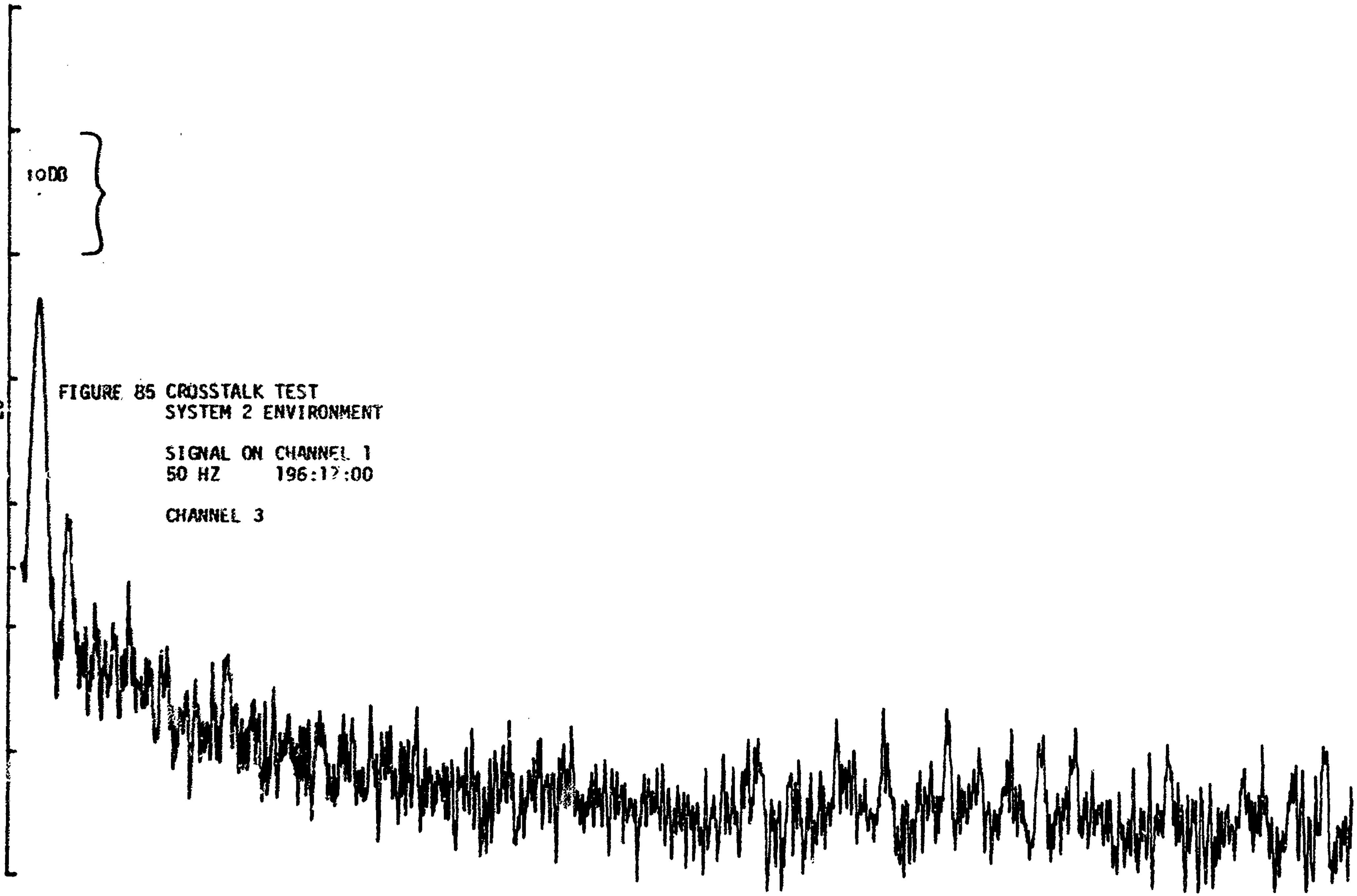


FIGURE 85 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 196:12:00

CHANNEL 3

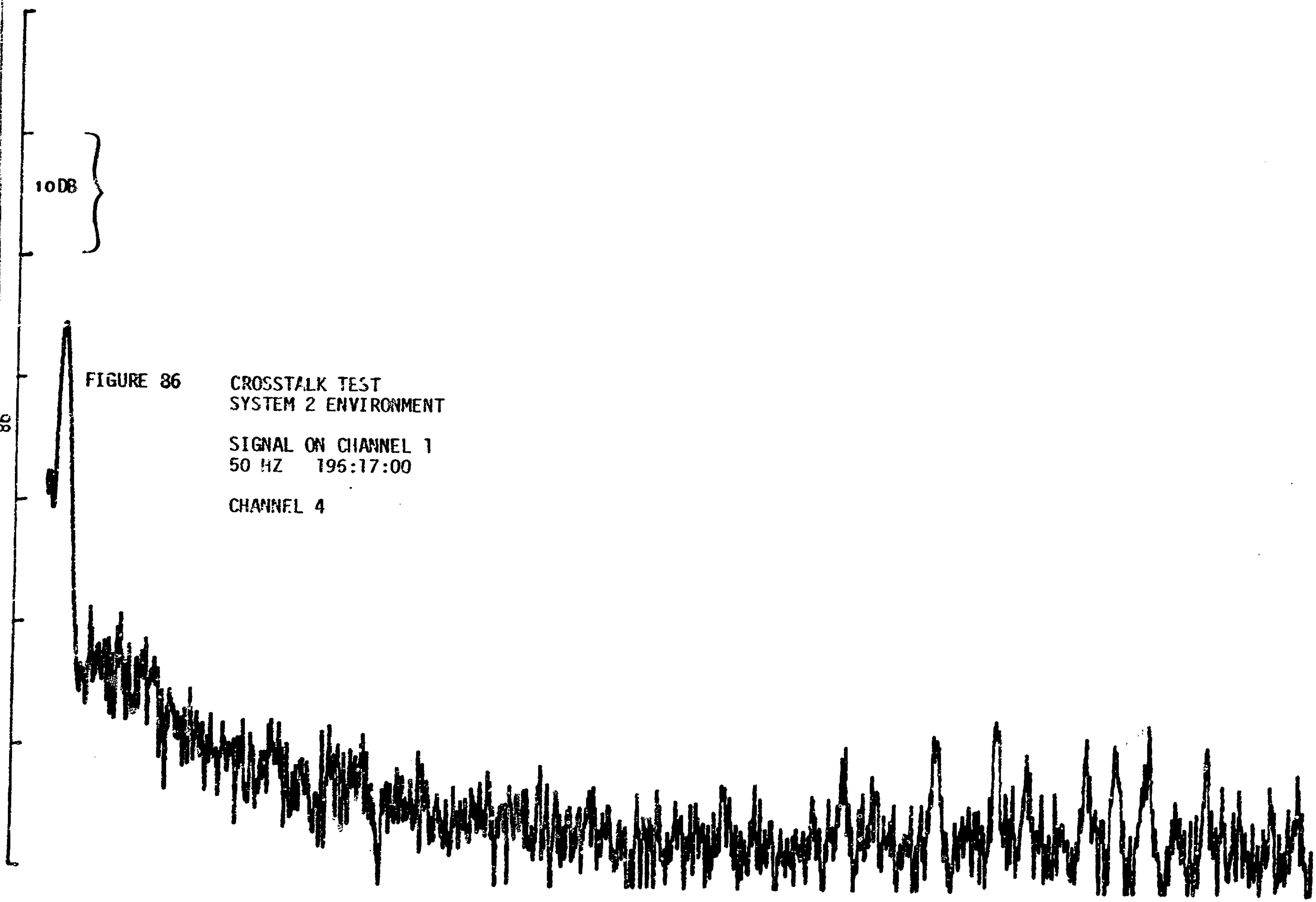


FIGURE 86

CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 196:17:00

CHANNEL 4

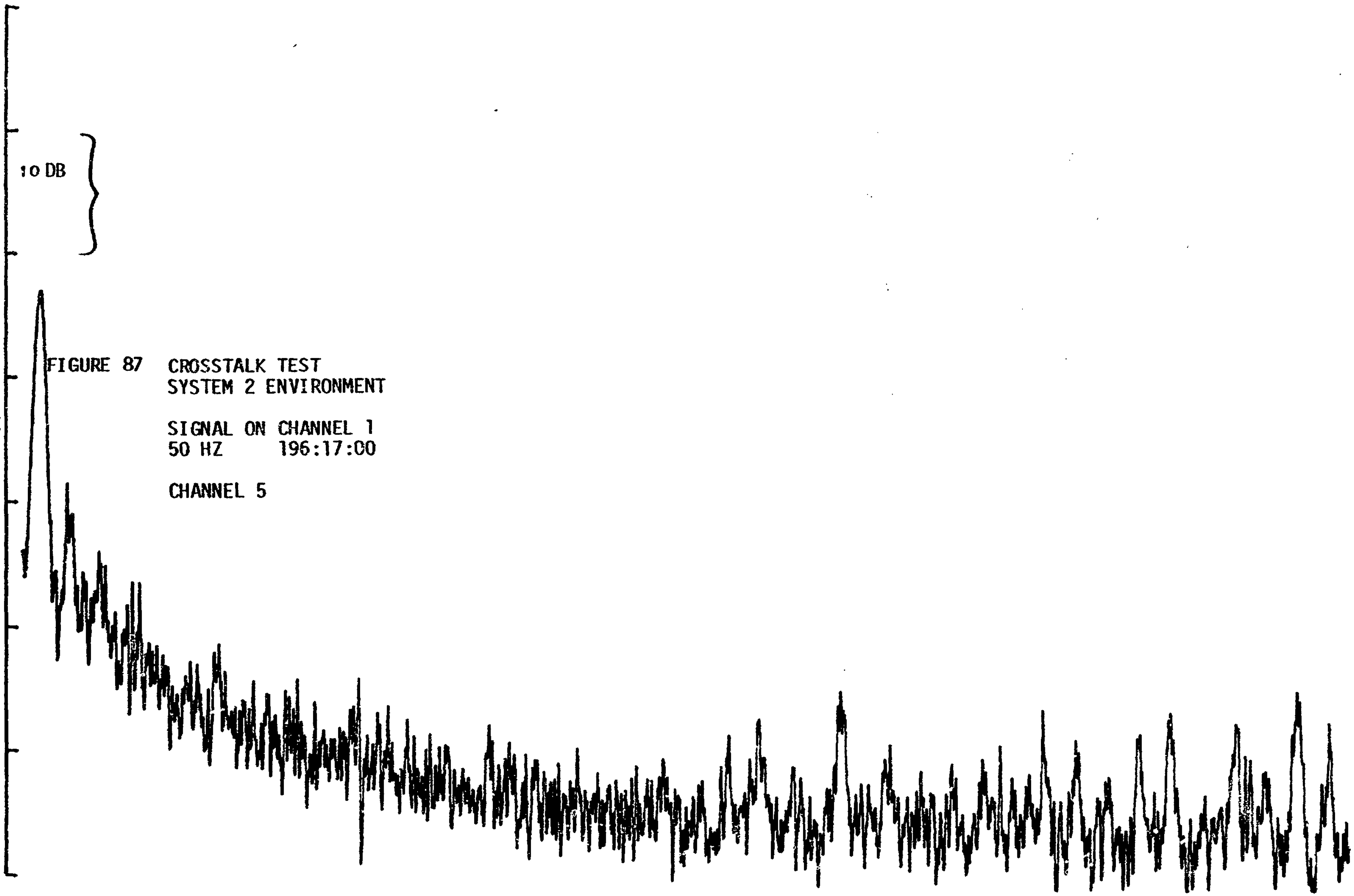


FIGURE 87 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 196:17:00

CHANNEL 5

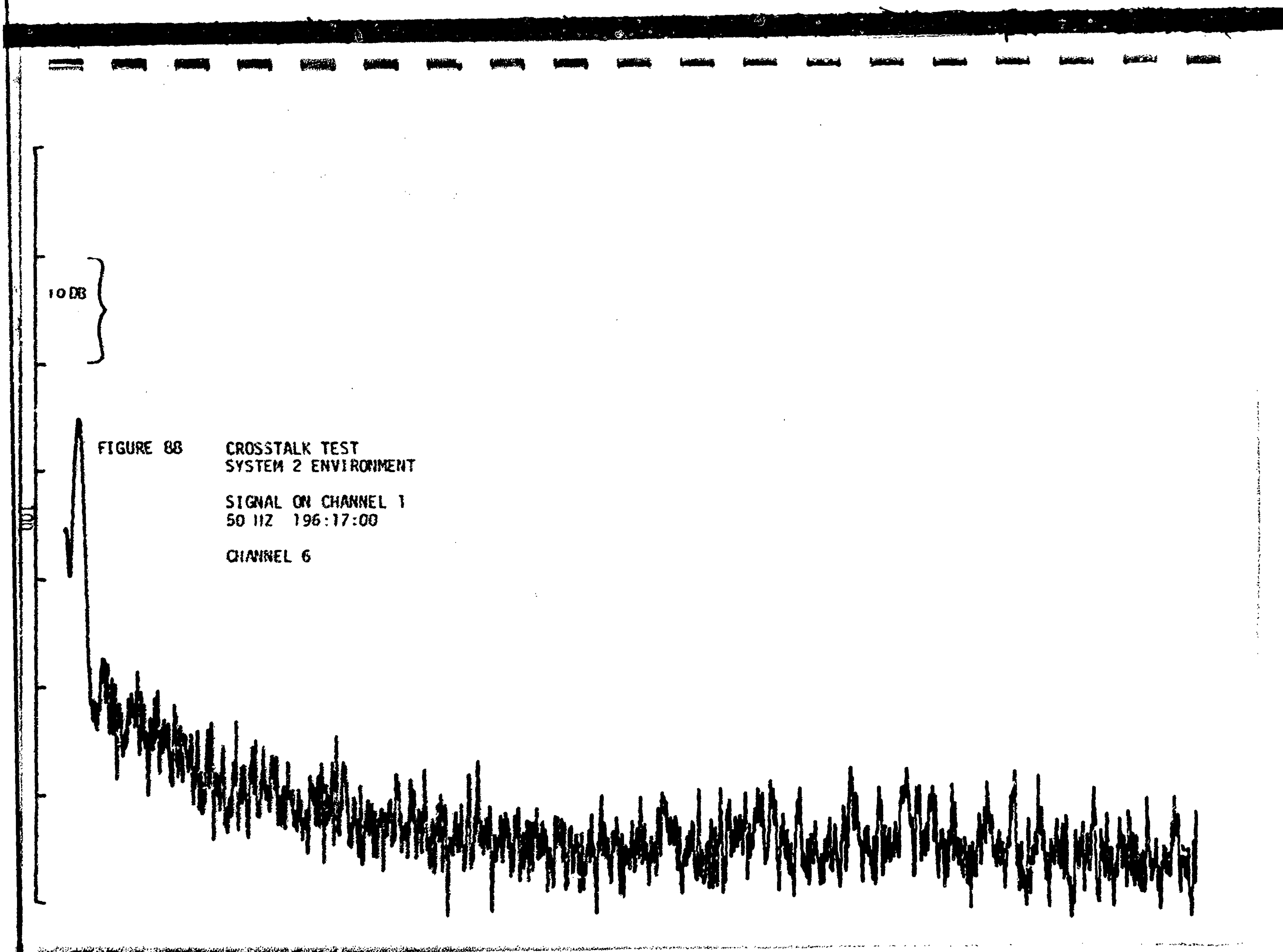


FIGURE 88 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 196:17:00

CHANNEL 6

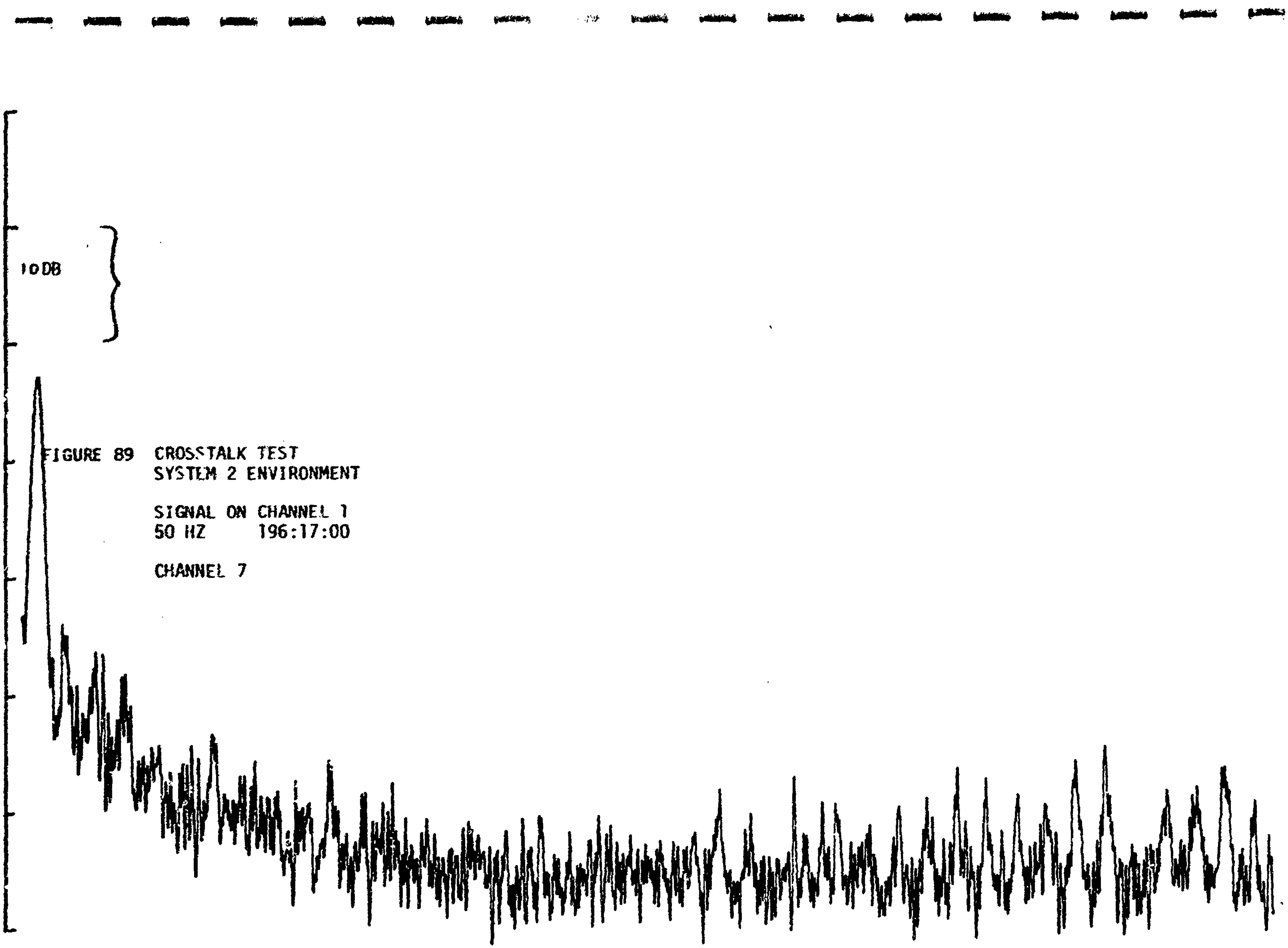


FIGURE 89 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 196:17:00

CHANNEL 7

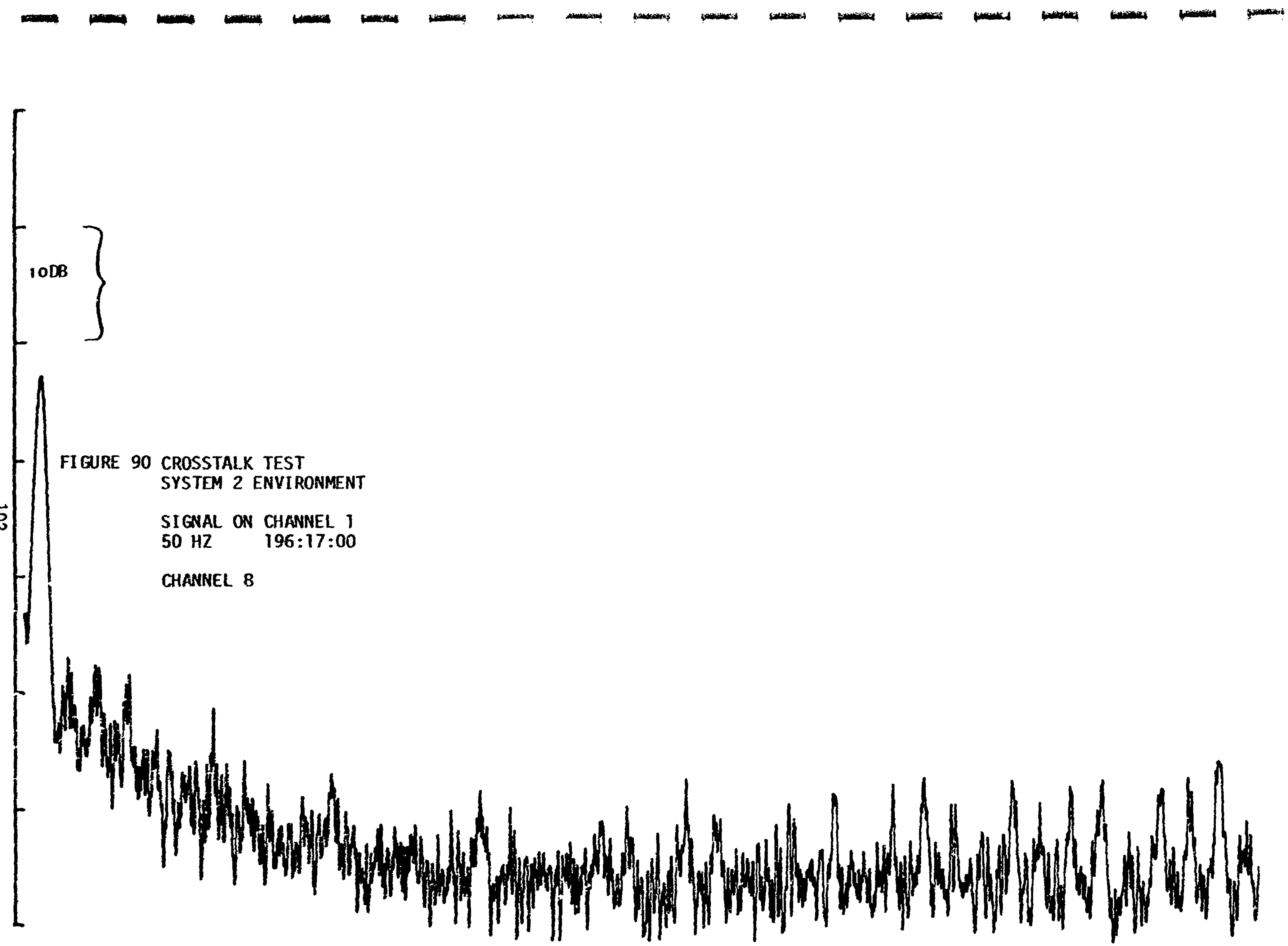


FIGURE 90 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 196:17:00

CHANNEL 8

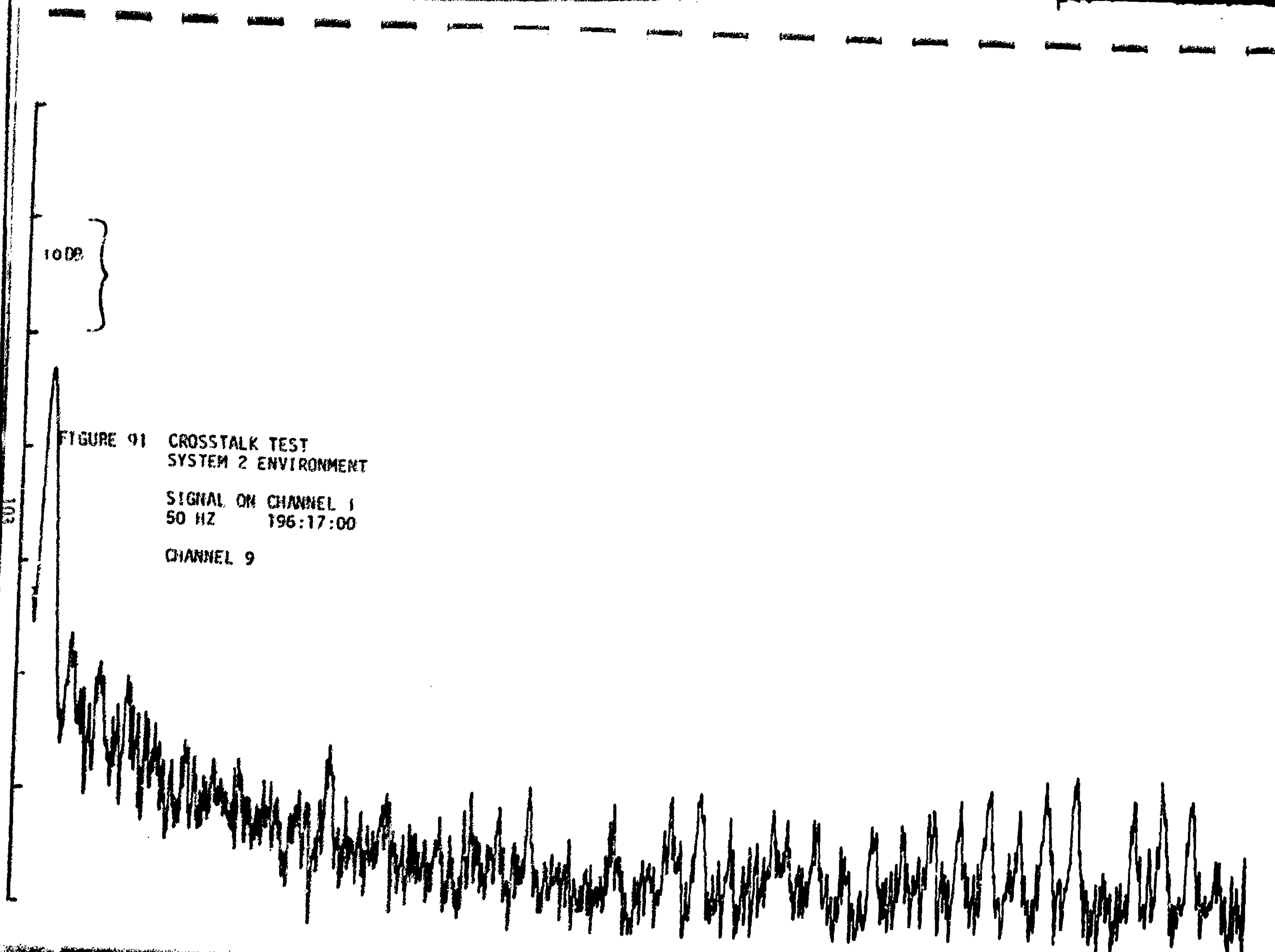


FIGURE 91 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 196:17:00

CHANNEL 9

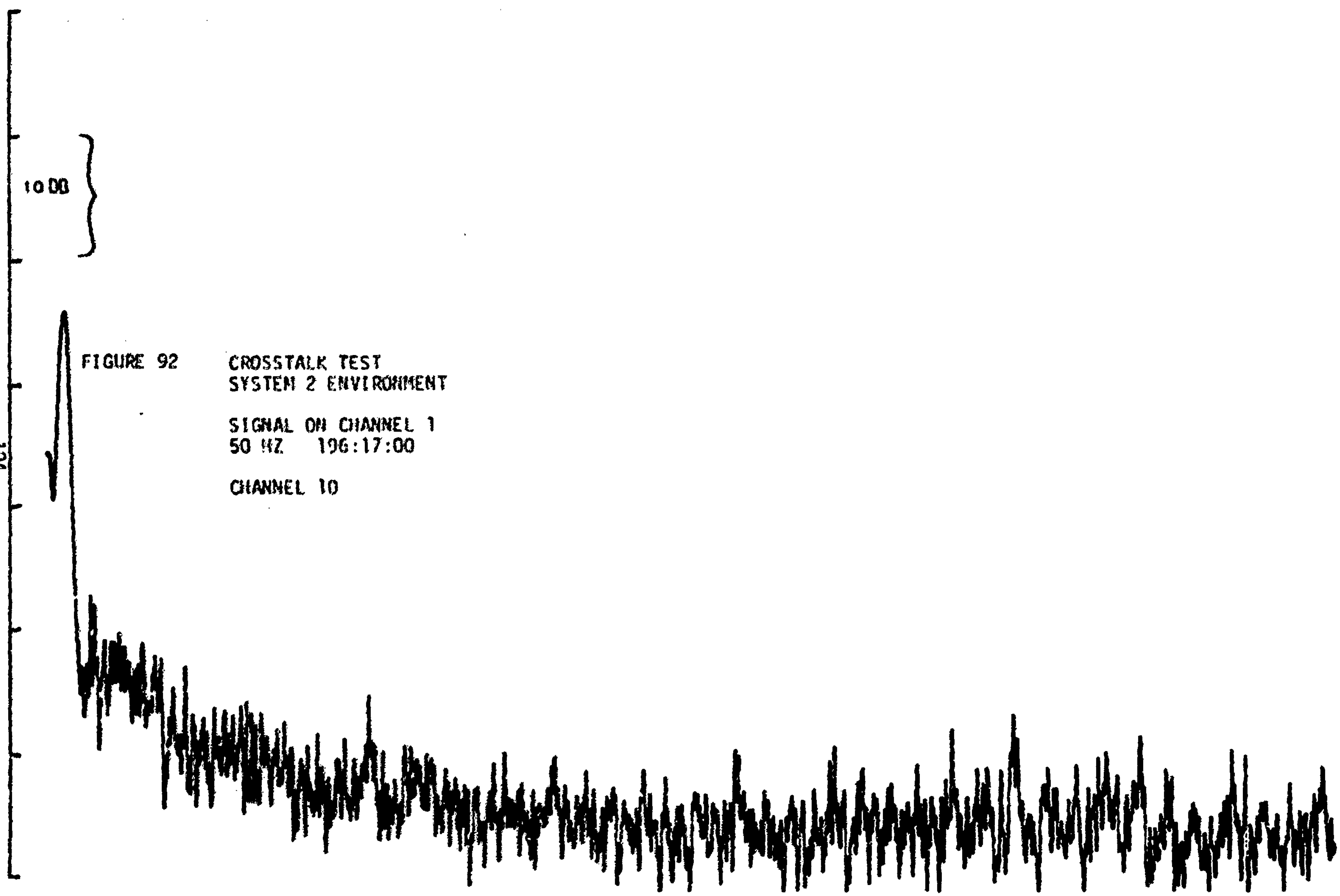
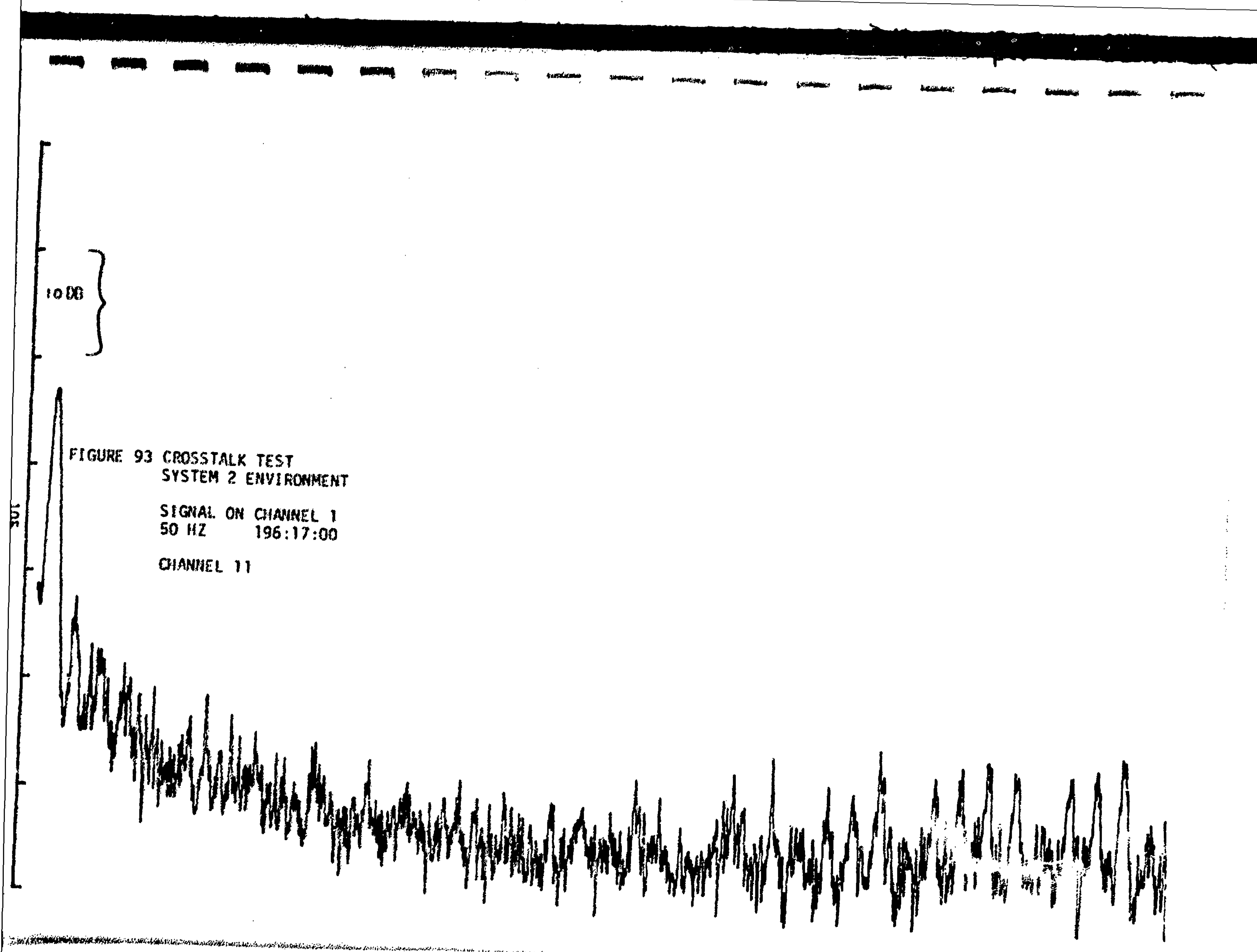


FIGURE 92 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 196:17:00

CHANNEL 10



10 DB
FIGURE 93 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT
SIGNAL ON CHANNEL 1
50 HZ 196:17:00
CHANNEL 11

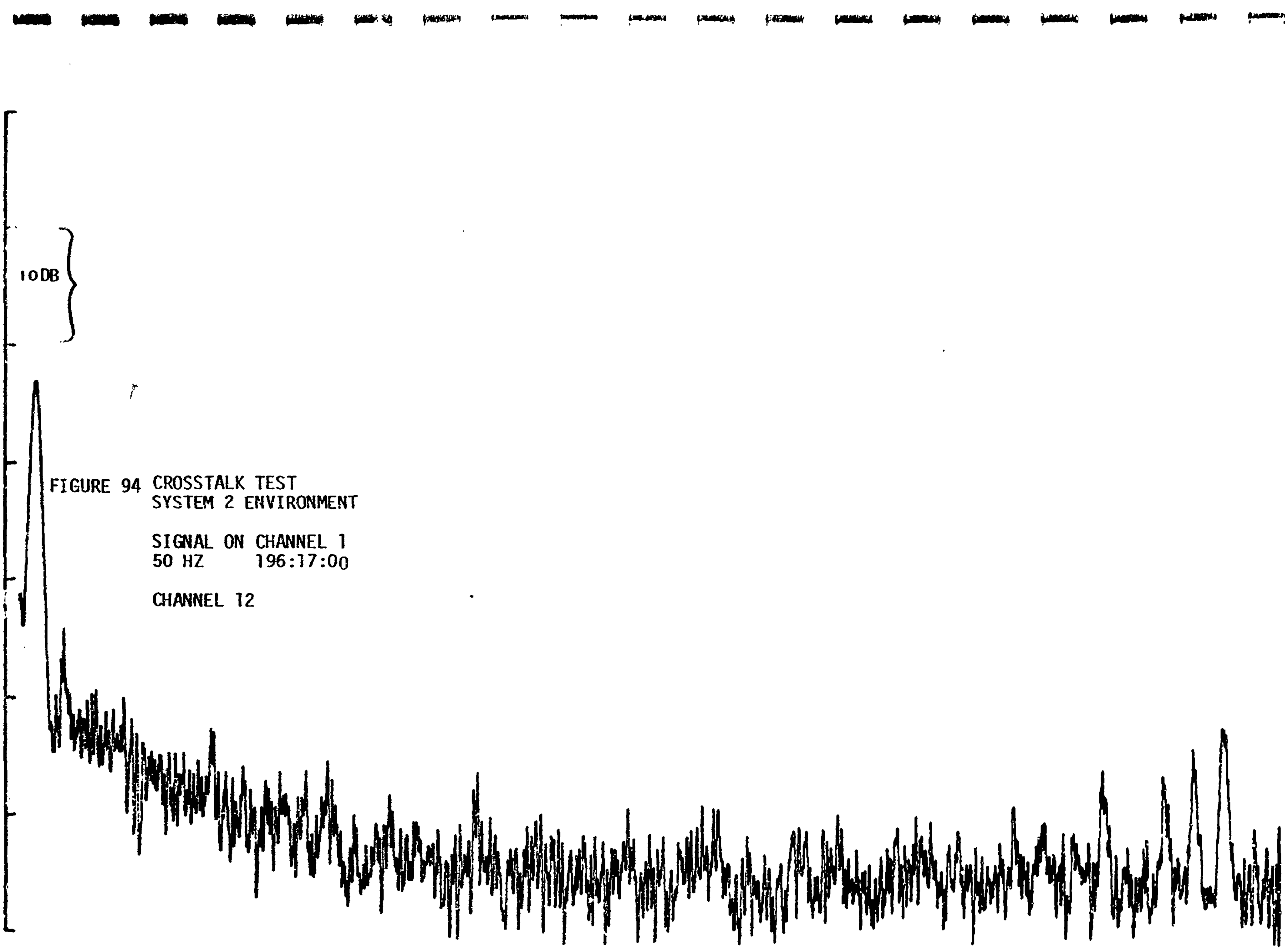


FIGURE 94 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 196:17:00

CHANNEL 12

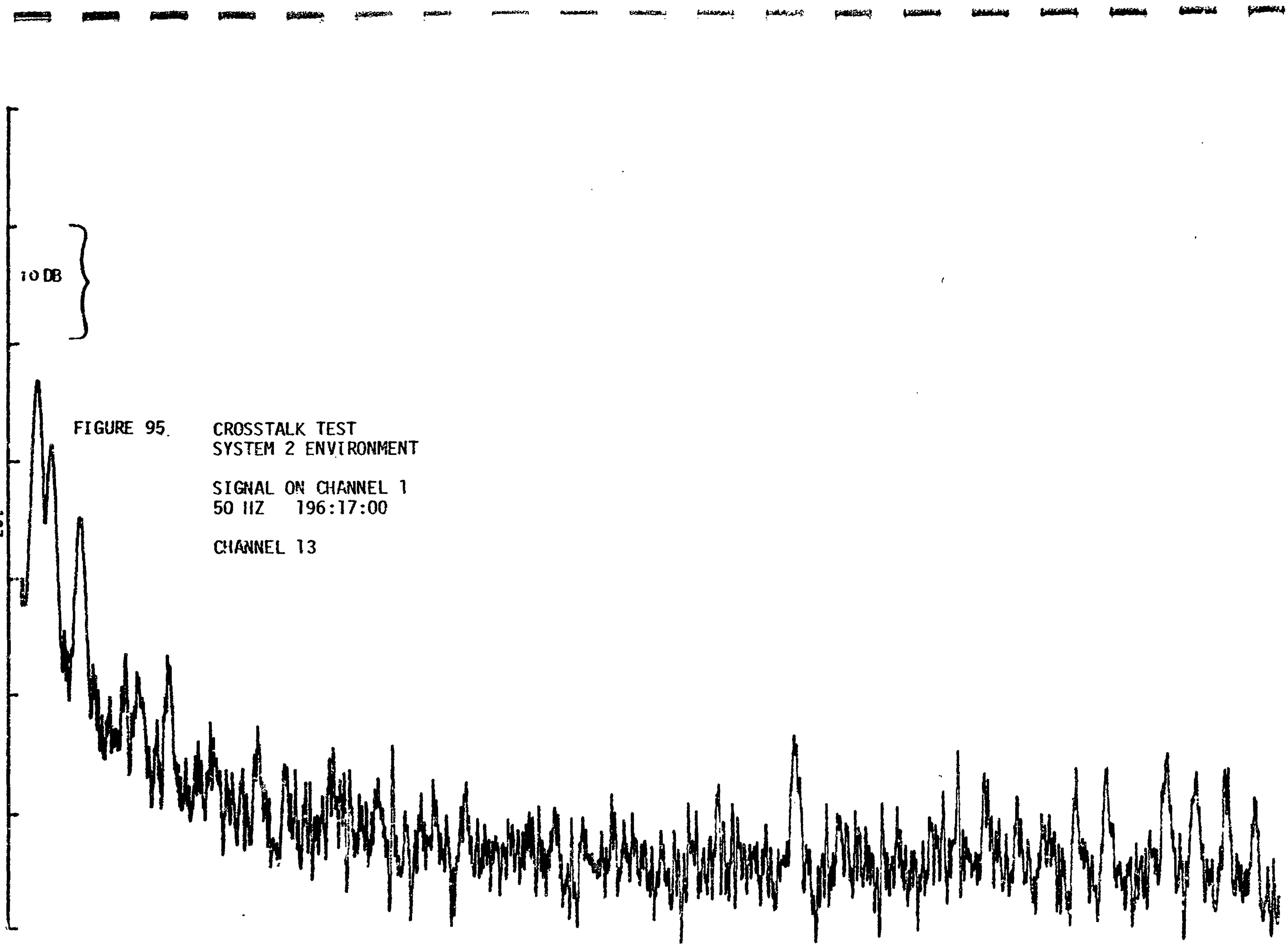


FIGURE 95. CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
50 HZ 196:17:00

CHANNEL 13

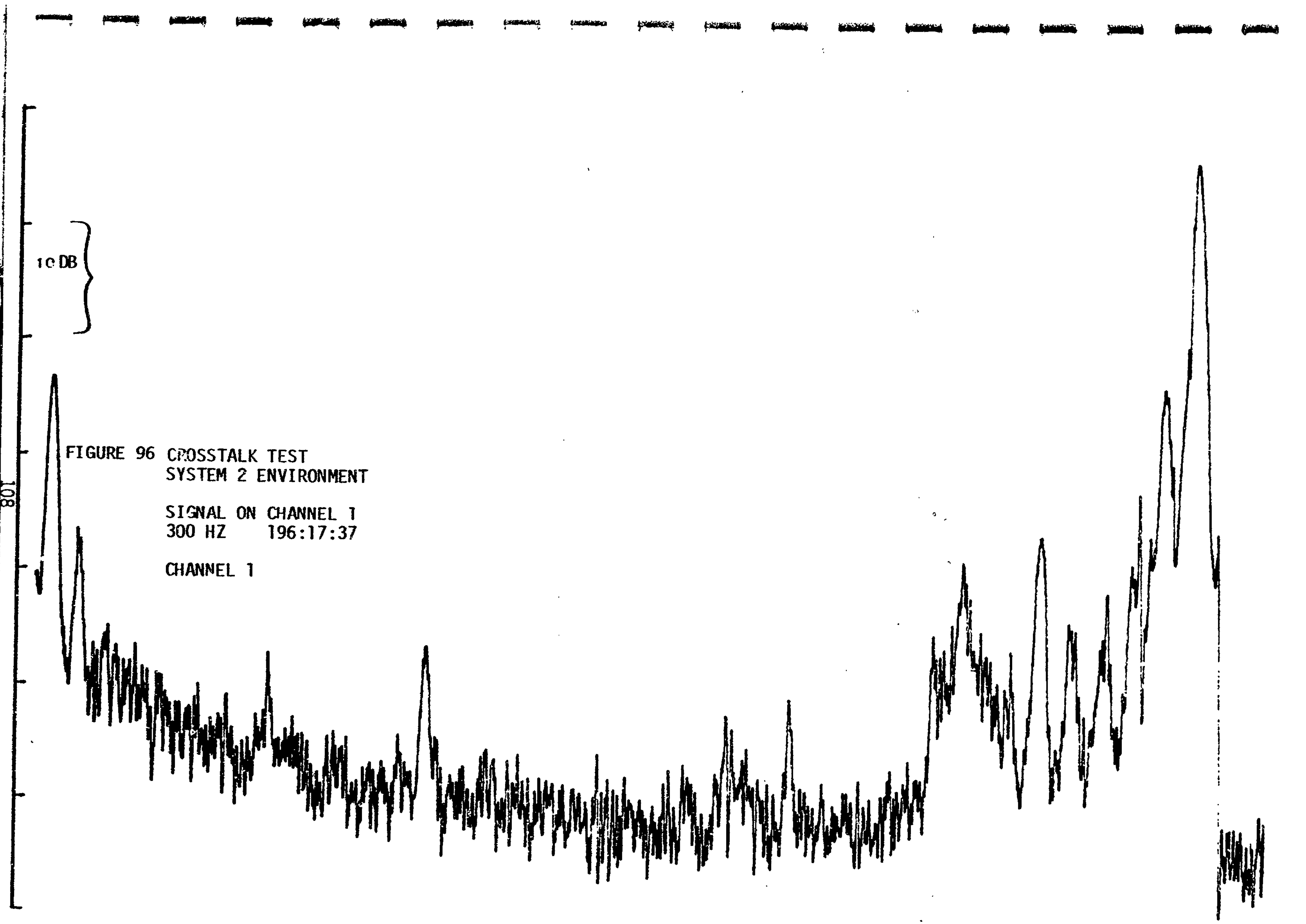


FIGURE 96 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 196:17:37

CHANNEL 1

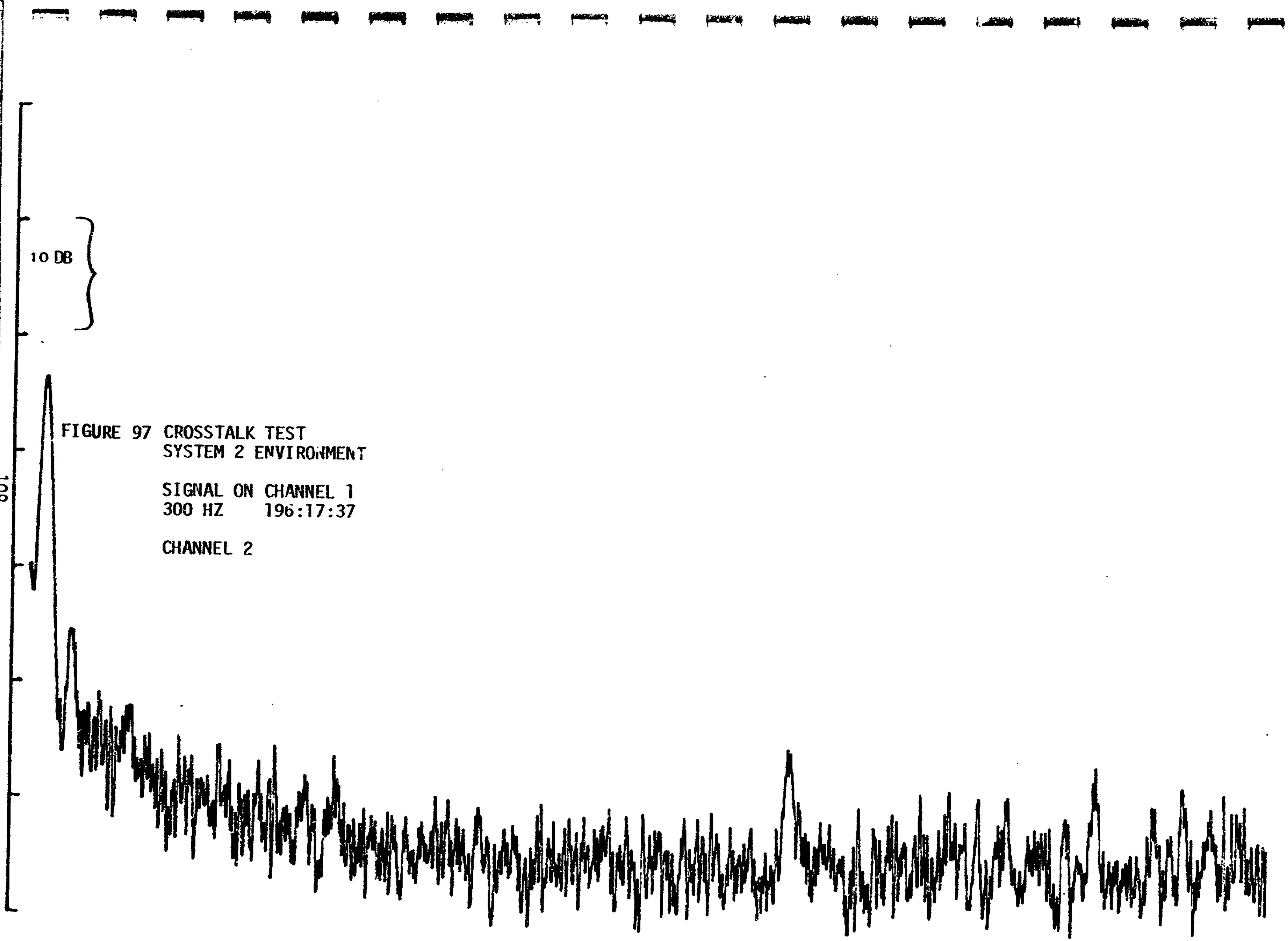


FIGURE 97 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 196:17:37

CHANNEL 2

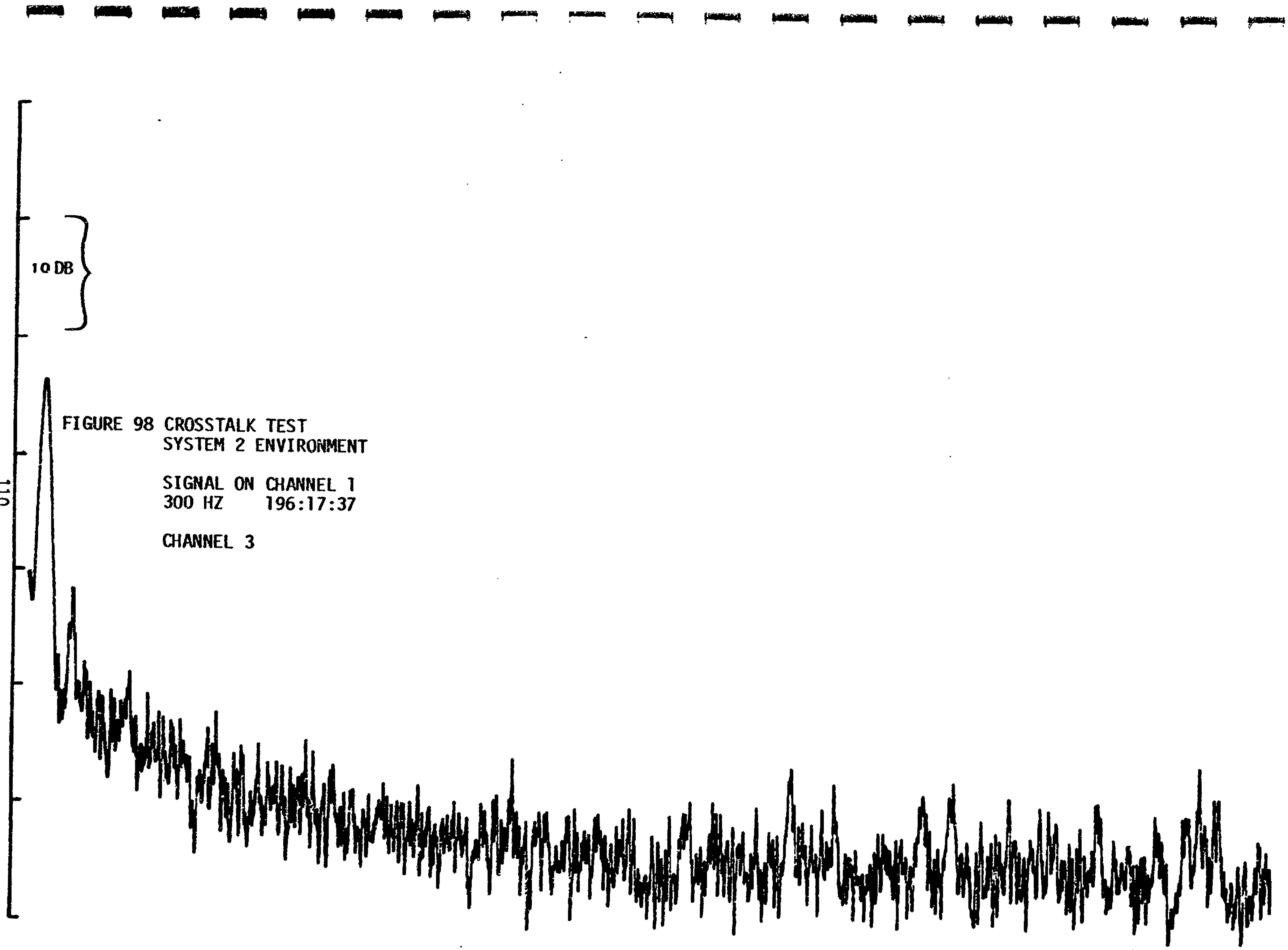


FIGURE 98 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 196:17:37

CHANNEL 3

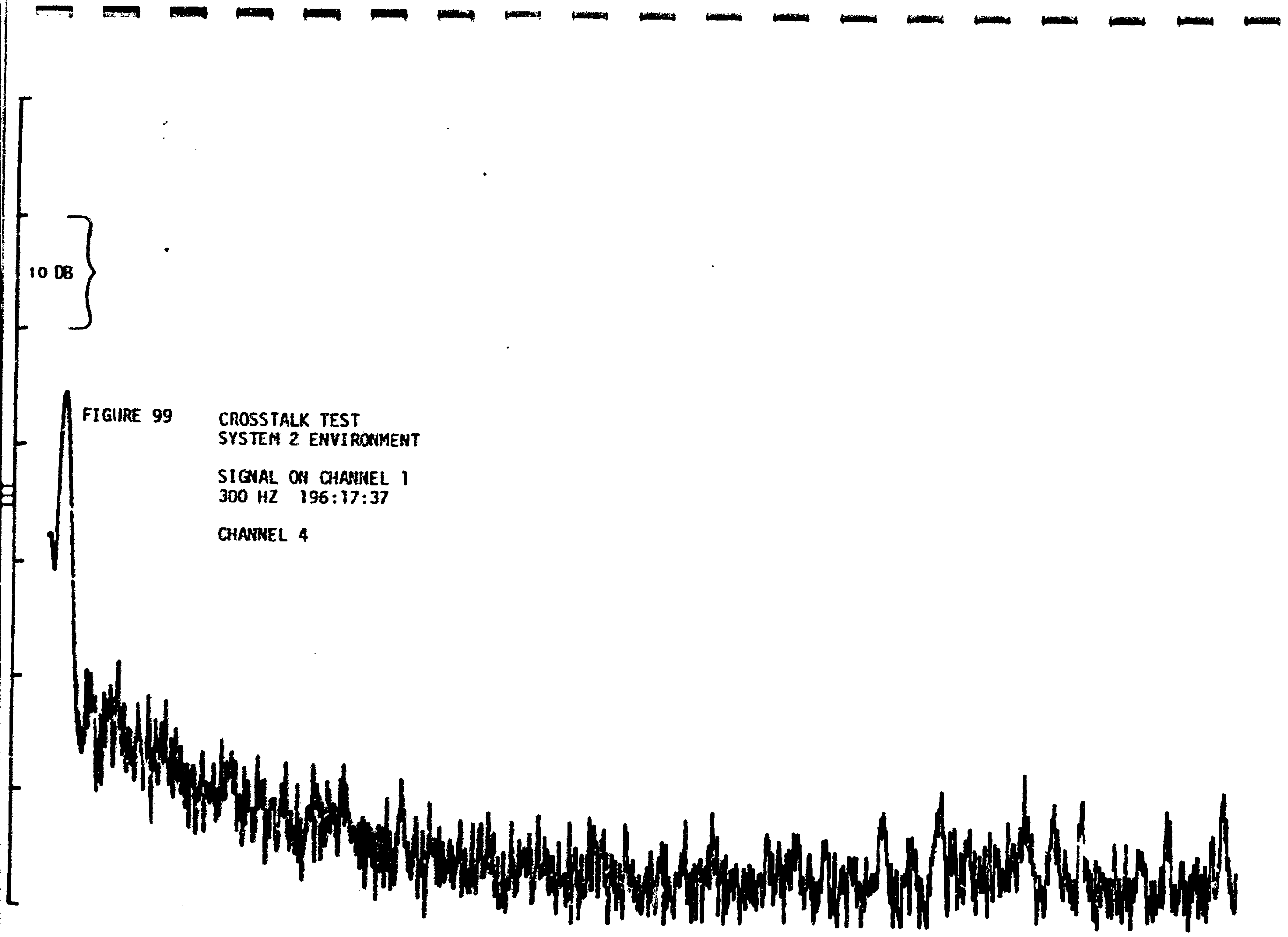


FIGURE 99 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 196:17:37

CHANNEL 4

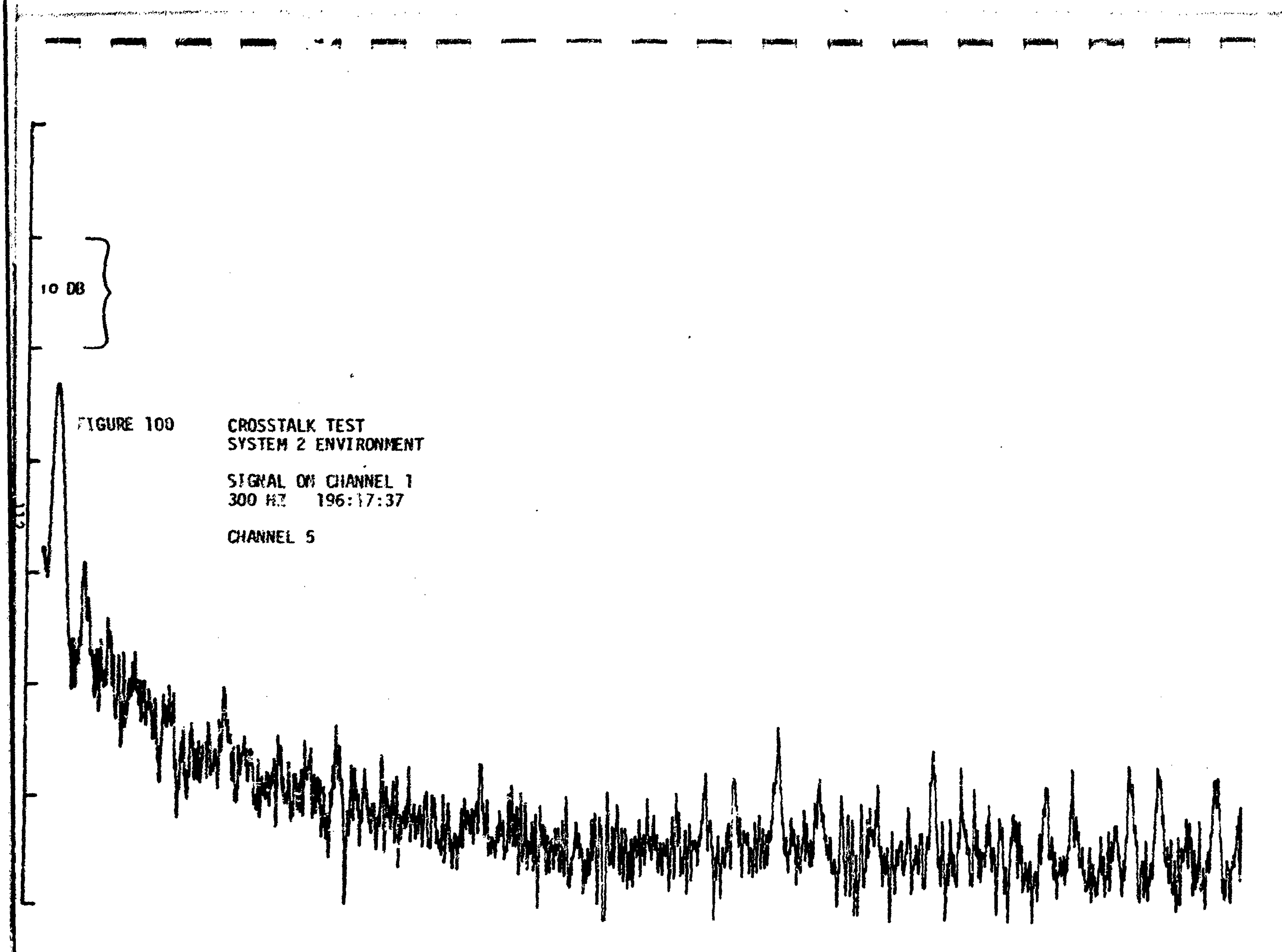


FIGURE 100 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 196:17:37

CHANNEL 5

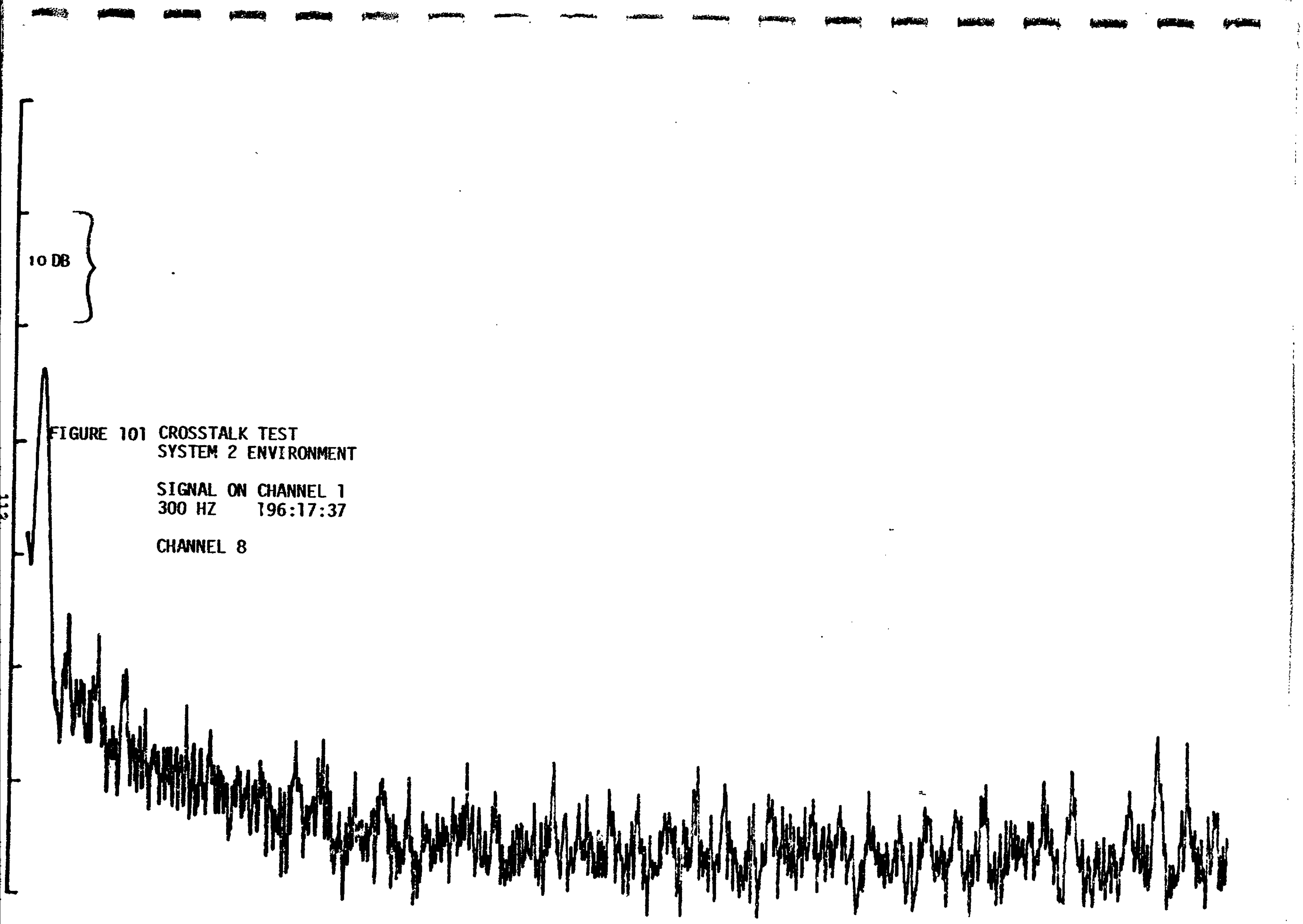


FIGURE 101 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 196:17:37

CHANNEL 8

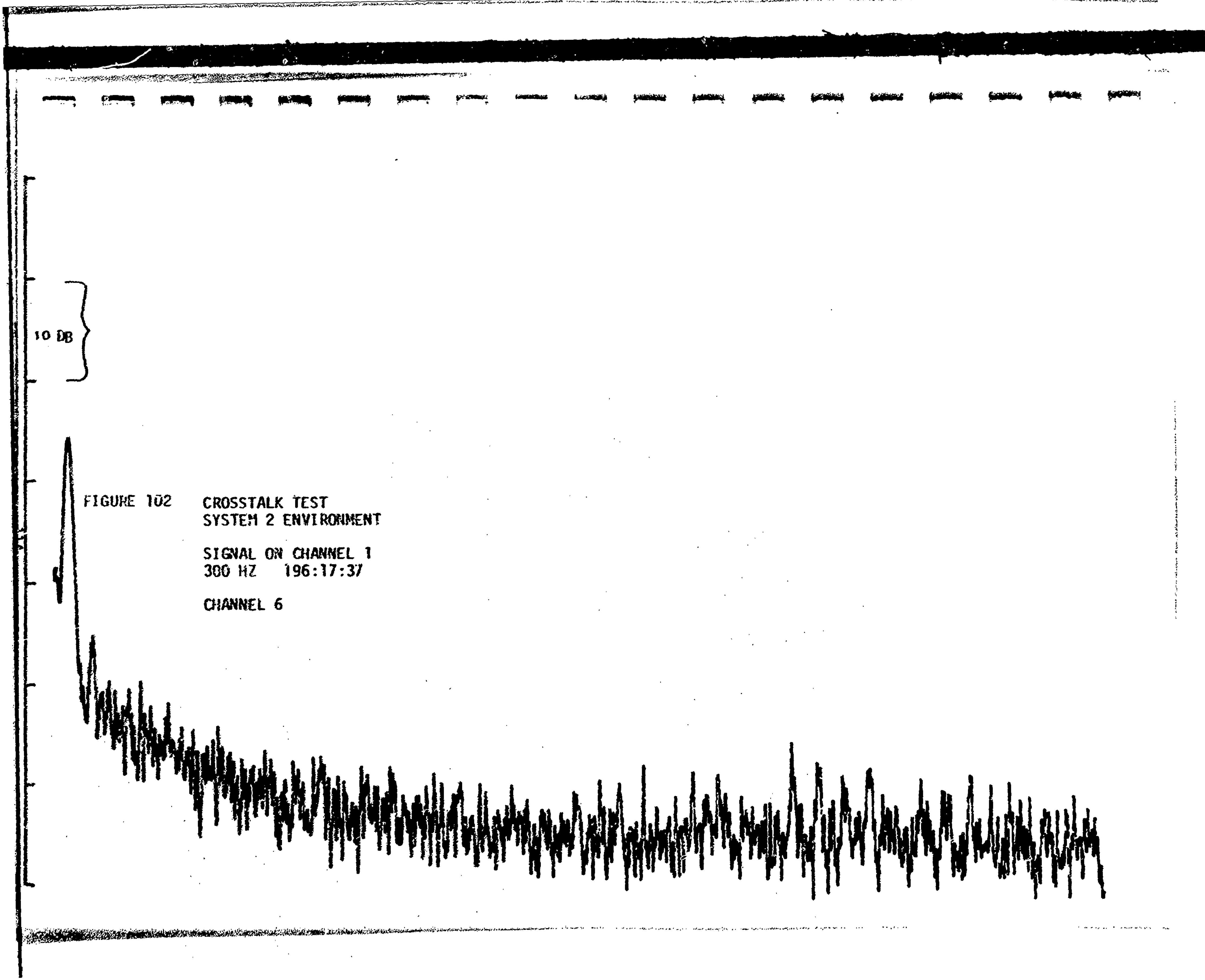


FIGURE 102 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 196:17:37

CHANNEL 6

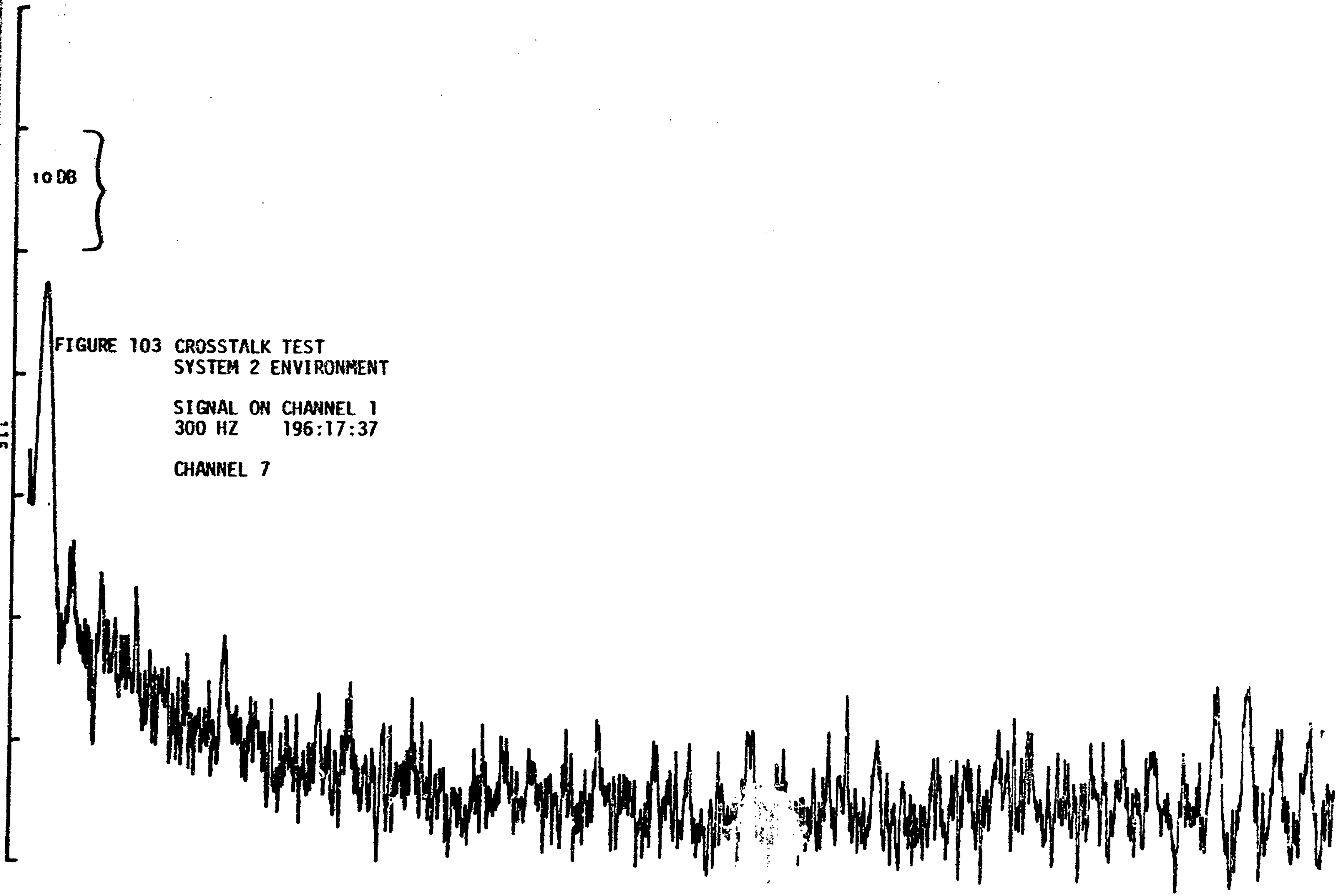


FIGURE 103 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 196:17:37

CHANNEL 7

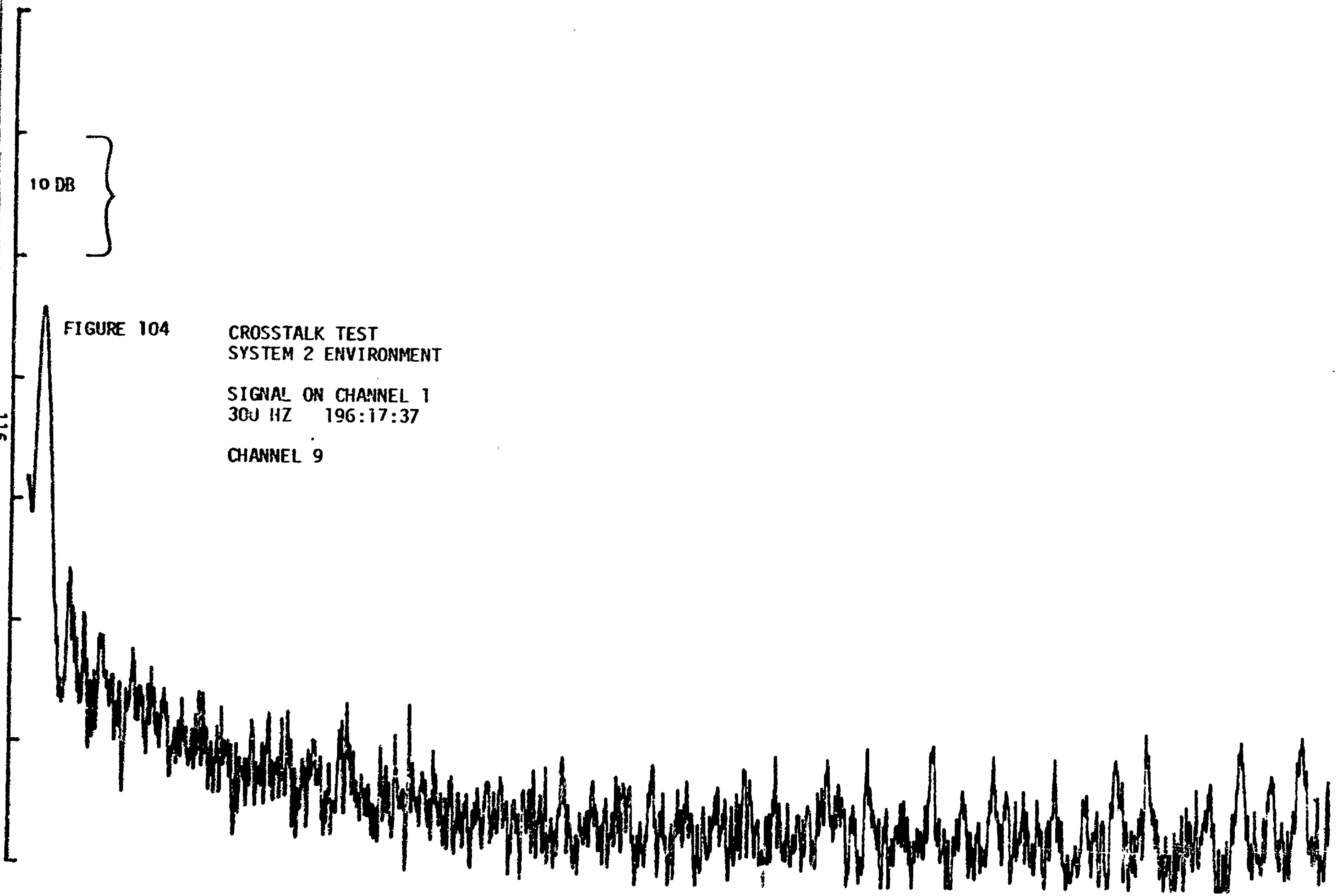


FIGURE 104

CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
30U HZ 196:17:37

CHANNEL 9

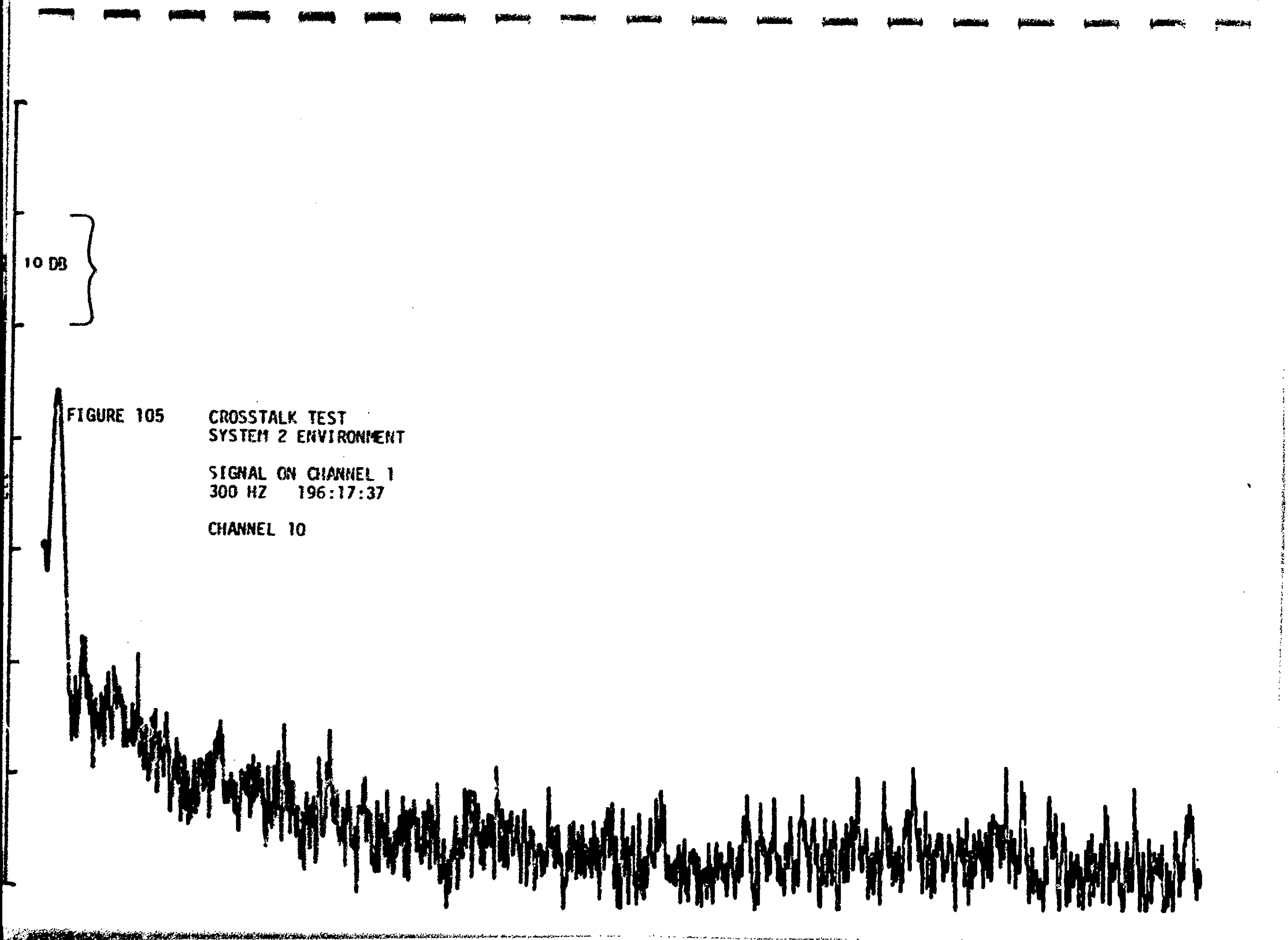


FIGURE 105 CROSSTALK TEST
SYSTEM 2 ENVIRONMENT

SIGNAL ON CHANNEL 1
300 HZ 196:17:37

CHANNEL 10

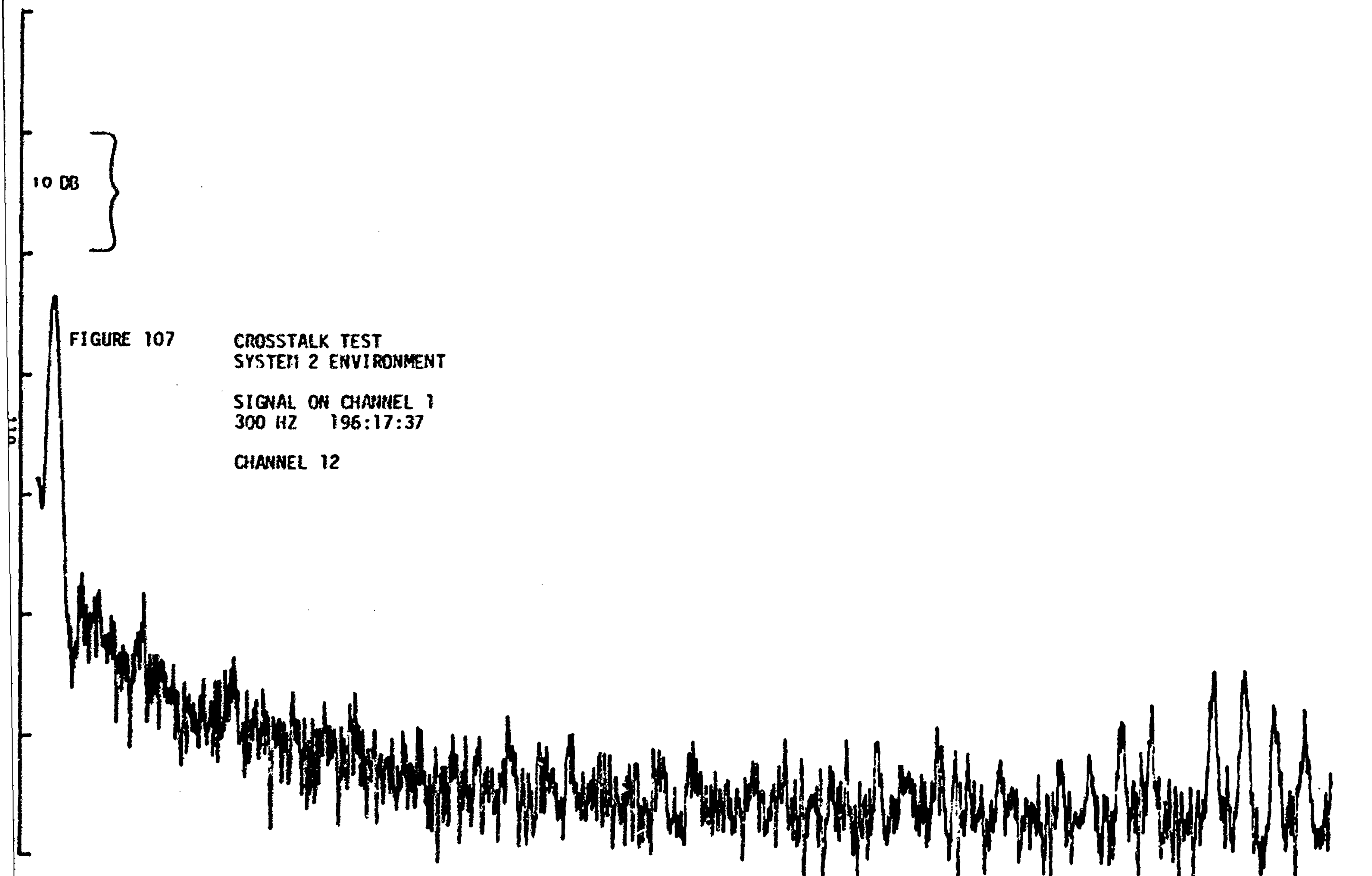
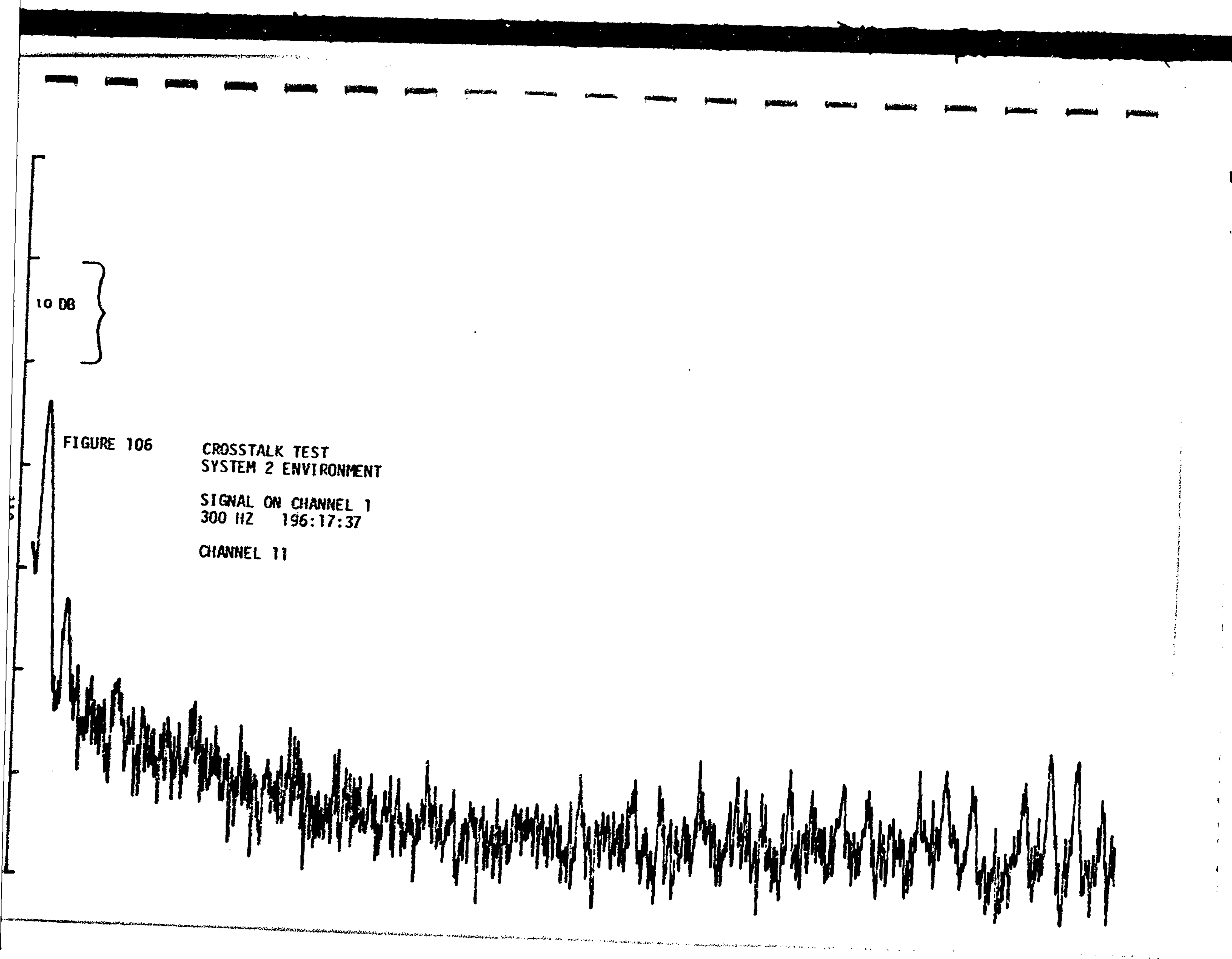

10 DB
110
CROSSTALK TEST
SYSTEM 2 ENVIRONMENT
SIGNAL ON CHANNEL 1
300 HZ 196:17:37
CHANNEL 12

FIGURE 107


10 DB
FIGURE 106
CROSSTALK TEST
SYSTEM 2 ENVIRONMENT
SIGNAL ON CHANNEL 1
300 HZ 196:17:37
CHANNEL 11

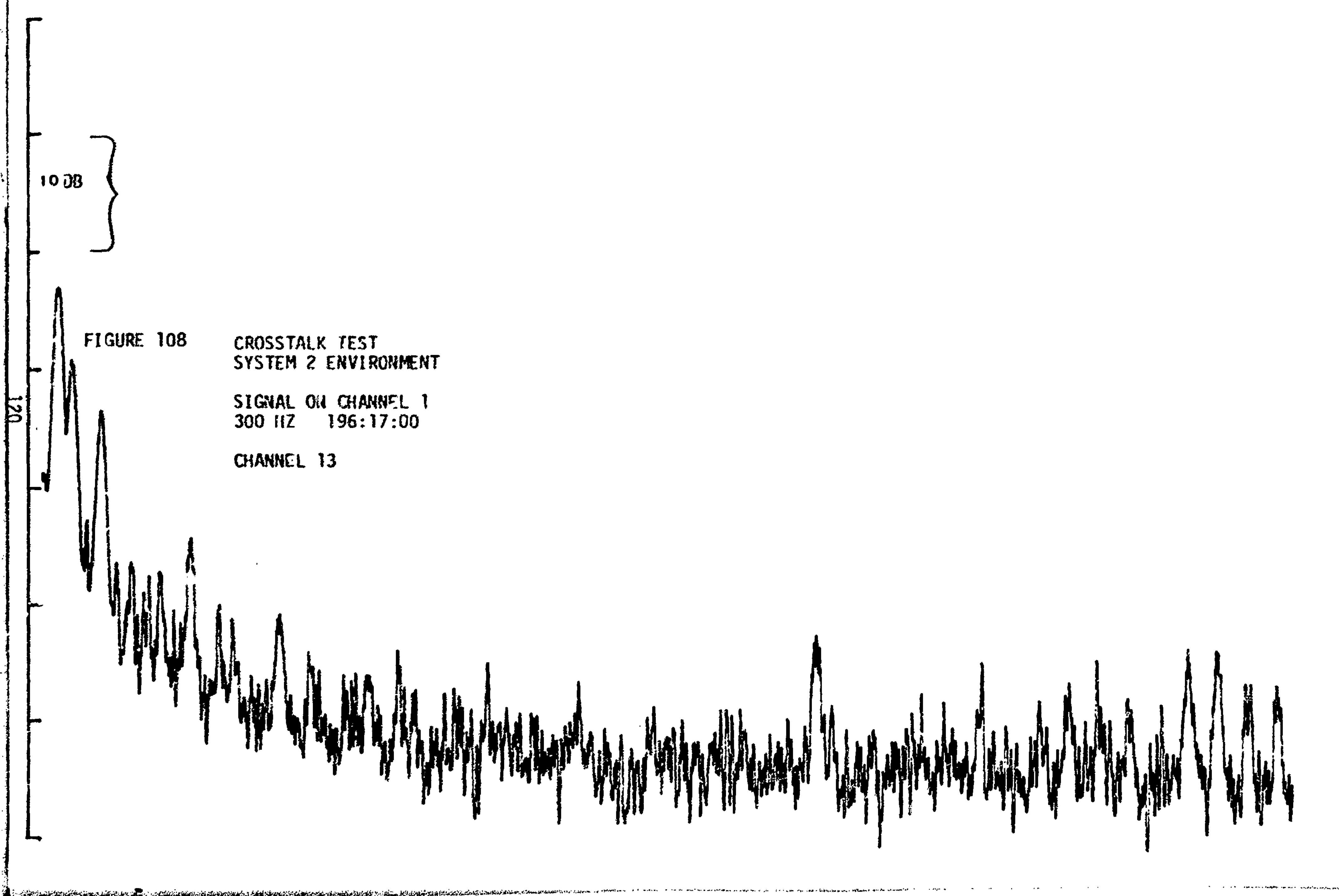

10 DB
120
FIGURE 108
CROSSTALK TEST
SYSTEM 2 ENVIRONMENT
SIGNAL ON CHANNEL 1
300 HZ 196:17:00
CHANNEL 13

FIGURE 109. PAR SYSTEM 2 LAB 20 AND 110HZ .316V GS = 0

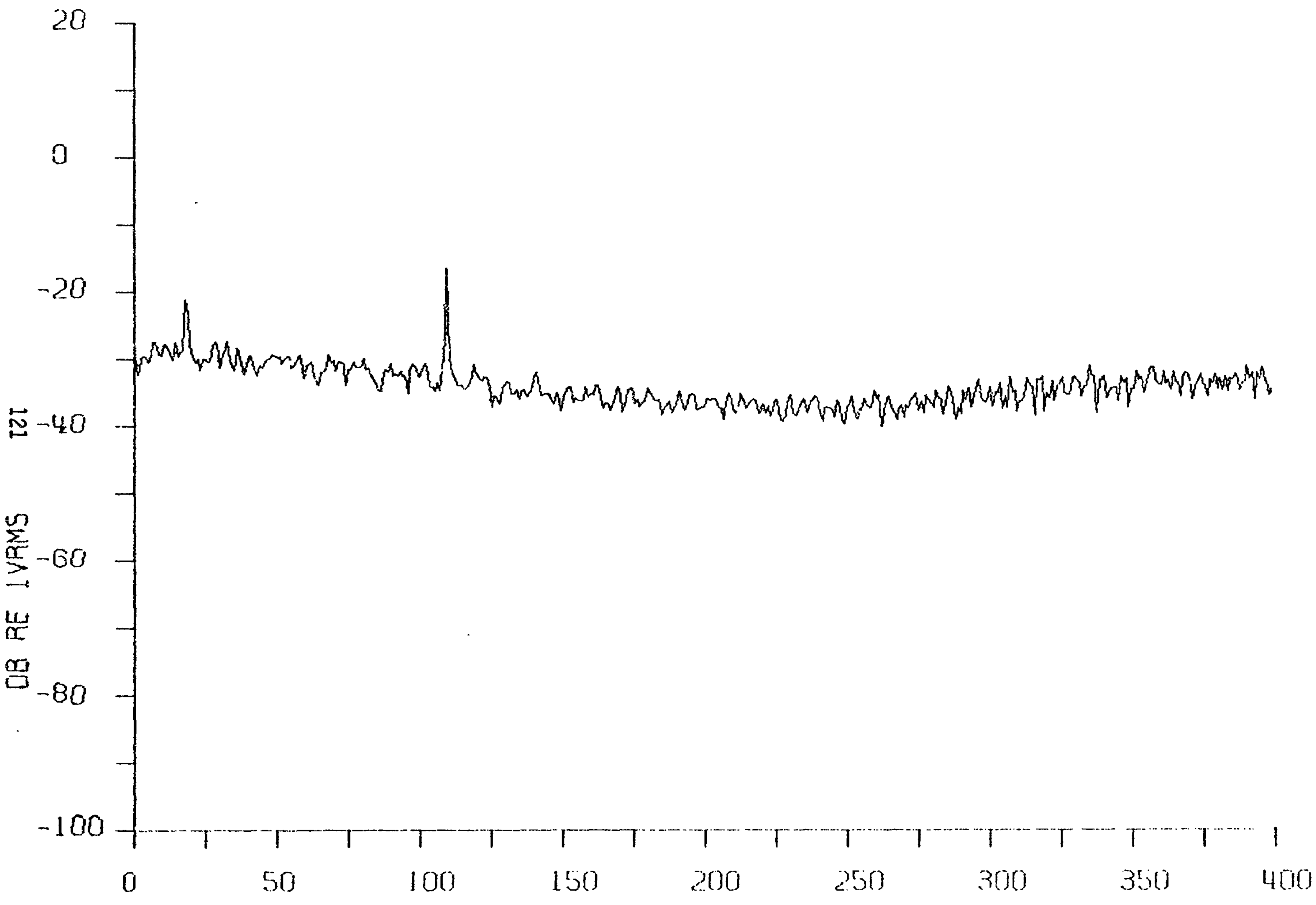
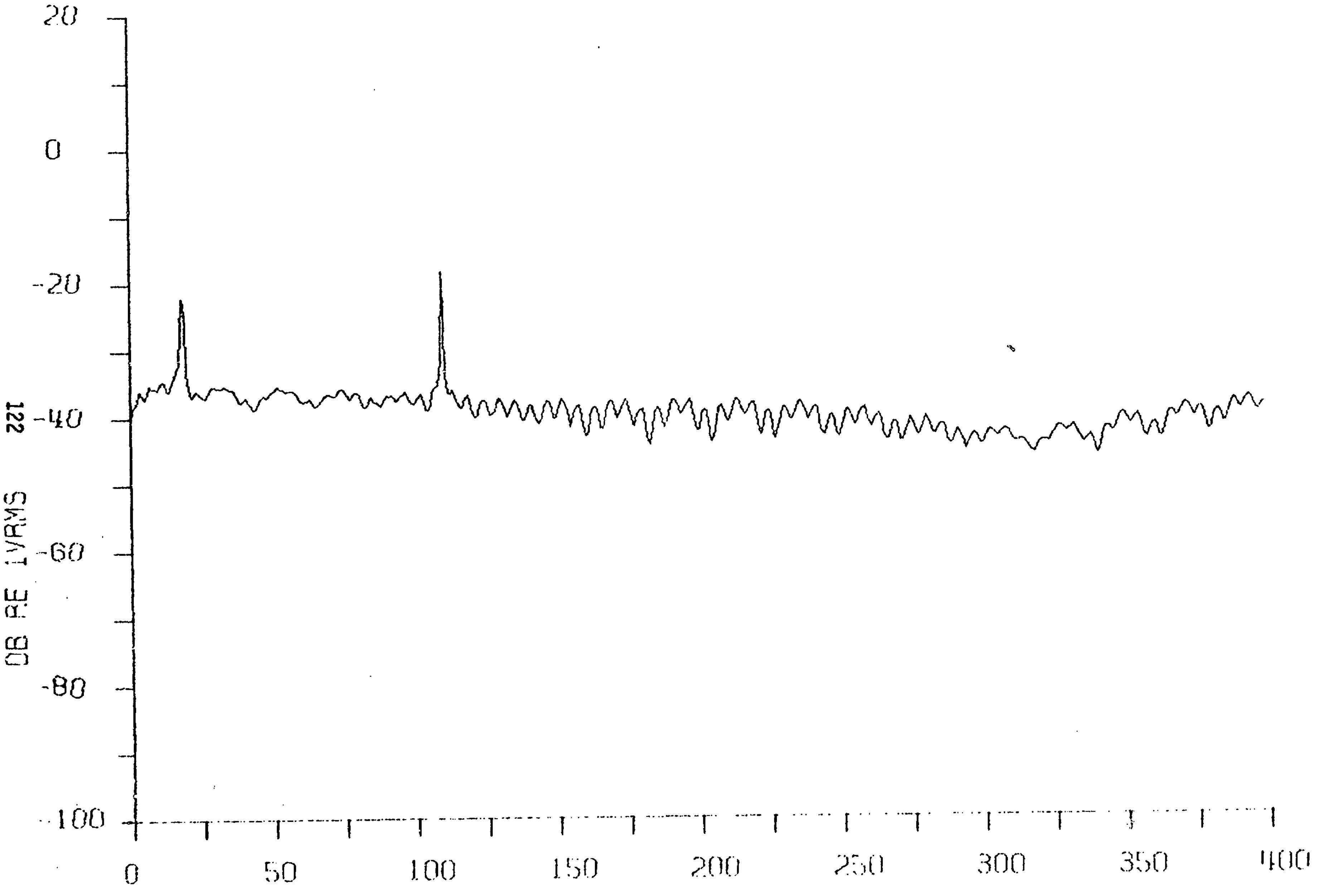


FIGURE 110. PAR SYSTEM 2 LAB CHANNEL 13 20 AND 110HZ W/NS GS = 0



All other channels under both laboratory and environmental conditions are expected to show similar characteristics, since no temperature dependence or interchannel variations have been noted in previous sections of data.

F. Conclusions

Data presented in this report has determined the operating characteristics of the PAR electronics packages. They have been shown to have similar characteristics for:

1. Linear Dynamic Range,
2. Gain Linearity,
3. Frequency Response,
4. Self Noise,
5. Interchannel Crosstalk,
6. Harmonic Distortion,
7. Frequency Modulation Noise,
8. Intermodulation Distortion.

Optimum record and bias levels have been determined, and the results of these determinations should provide a significant pool of fundamental data on the PAR systems which will be a valuable tool in the reduction and analysis of ocean acoustic data.

V. Acoustic Data Capsule (ACODAC) Technical Summary

Modification P00008 called for a refurbishment and an upgrade of two ACODAC units, to make them similar to the PAR units. New circuits such as electronic switching and differential transmission of data were added, and rewiring was performed as required. Attachment IV of P00008 lists the specific tasks performed on the ACODAC's. Note these changes:

a. Instead of 9 differential input channels, 13 are available.
b. Instead of 9 preemphasis channels, each ACODAC has 12 available.
c. Modifications of existing data amps were performed to return them to the original design (except the error signal has been disabled).
d. Modifications on relay driver and brake control were performed to allow for more efficiency with the WHOI time code generator. Mechanical refurbishment has been performed according to task requirements.

VI. Summary

The development and construction of the PAR/ACODAC electronics and the development of the complimentary software have been completed under this contract, N00014-75-C-0107. Deployment and results from the sea testing of the PAR/ACODAC equipment will be reported under Contract N00014-77-C-0776.

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2. The LRAPP documents listed in enclosure (1) have been downgraded to UNCLASSIFIED and have been approved for public release. These documents should be remarked as follows:

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Report Number	Personal Author	Title	Publication Source (Originator)	Pub. Date	Current Availability	Class.
DASC 012-C-77	Unavailable	LRAPP PACIFIC DYNAMIC ARCHIVE (U) SEPTEMBER 1976	Daniel Analytical Services Corporation	770201	NS; ND	U
SAI-78-527-WA	Spofford, C. W.	NELANT DATA ASSESSMENT APPENDIX III-MODELING REPORT	Science Applications, Inc.	770225	ND ADA 047680	U
PSI TR 036049	Barnes, A. E., et al.	OCEAN ROUTE ENVELOPES	Planning Systems Inc.	770419	ND	U
Unavailable	Unavailable	TAP II BEAMFORMING SYSTEM SOFTWARE FINAL REPORT	Bunker-Ramo Corp. Electronic Systems Division	770501	ADC011789	U
S01037C8	Unavailable	TAP 2 PROCESSING SYSTEM FINAL REPORT HARDWARE DOCUMENTATION (U)	Bunker-Ramo Corp. Electronic Systems Division	770501	ADC011790; NS; ND	U
Unavailable	Weinberg, H.	GENERIC FACT	Naval Underwater Systems Center	770601	ADB019907	U
Unavailable	Unavailable	TASSRAP II OB SYSTEM TEST	Analysis and Technology, Inc.	770614	ADA955352	U
Unavailable	Unavailable	LRAPP TECHNICAL SUPPORT	Texas Instruments, Inc.	770624	ND	U
Unavailable	Bessette, R. J., et al.	TASSRAP INPUT MODULE	Analysis and Technology, Inc.	770729	ADA955340	U
Unavailable	Unavailable	TAP-II PHASE II FINAL REPORT	Bunker-Ramo Corp. Electronic Systems Division	770901	ADC011791	U
Unavailable	Unavailable	LONG RANGE ACOUSTIC PROPAGATION PROJECT (LRAPP)	Xonics, Inc.	770930	ADA076269	U
SAI78696WA	Unavailable ADA 05728	REVIEW OF MODELS OF BEAM-NOISE STATISTICS (U)	Science Applications Inc.	771101	NS; ND	U
TRACORT77RV109 C	Unavailable	FINAL REPORT FOR CONTRACT N00014-76-C-0066 (U)	Tracor Sciences and Systems	771130	ADC012607; NS; ND	U
Unavailable	Unavailable	LONG RANGE ACOUSTIC PROPAGATION PROJECT (LRAPP)	Xonics, Inc.	771231	ADB041703	U
Unavailable	Homer, C. I.	SUS SOURCE LEVEL ERROR ANALYSIS ADA C556CC	Underwater Systems, Inc.	780120	ND	U
Unavailable	Fitzgerald, R. M.	LOW-FREQUENCY LIMITATION OF FACT	Naval Research Laboratory	780131	ADA054371	U
Unavailable	Unavailable	MIDWATER ACOUSTIC MEASUREMENT SYSTEM - PAR AND ACODAC	Texas Instruments, Inc.	780228	ADB039924	U
ORI TR 1245	Moses, E. J.	OPTIONS, REQUIREMENTS, AND RECOMMENDATIONS FOR AN LRAPP ACOUSTIC ARRAY PERFORMANCE MODEL	ORI, Inc.	780331	ND	U
Unavailable	Hosmer, R. F., et al.	COMBINED ACOUSTIC PROPAGATION IN EASTPAC REGION (EXERCISE CAPER): INITIAL ACOUSTIC ANALYSIS	Naval Ocean Systems Center	780601	ADB032496	U
LRAPPRC78023	Watrous, B. A.	LRAPP EXERCISE ENVIRONMENTAL DATA INVENTORY, JUNE 1978 (U)	Naval Ocean R&D Activity	780601	NS; ND	U
TR052085	Solomon, L. P., et al.	HISTORICAL TEMPORAL SHIPPING (U) ADB C371 C?	Planning Systems Inc.	780628	NS; ND	U

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